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ABSTRACT

This collection of 8 papers from the Seventeenth Annual Telecommunications Policy Research Conference includes: (1) "The Measurement, Evaluation, and Encouragement of Telephone Service Quality" (S. Berg and J. Lynch, Jr.); (2) "Impacts of Deregulation and Competition on the PBX/Centrex Market" (H. Ware); (3) "The Quasi-Public Network: Issues of Pricing and Access" (B. Kahin); (4) "The New Zealand Spectrum Project: Description and Observations" (C. Jackson and R. Foster); (6) "The Total and Partial Factor Productivity of the Nippon Telegraph and Telephone Co." (H. Oniki, T. Oum, and R. Stevenson); (6) Integrated Broadband Networks: The Role of the Cable Companies" (D. Reed and M. Sirbu); (7) "Market Concentration in the Entertainment Industry" (D. Gomery); and (8) "Profiles and Testing: The New Standards Challenge" (D. Cerni). (GL)

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THE TELECOMMUNICATIONS POLICY RESEARCH CONFERENCE

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September 21, 1989

The Measurement, Evaluation, and Encouragement of Telephone Service Quality

by Sanford V. Berg
and
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ABSTRACT

Telephone service quality is an important but understudied aspect of industry performance. In order to evaluate industry performance in response to new technological opportunities and a new regulatory environment, we must be able to measure quality over time (and across firms), evaluate the many dimensions of service quality in terms of some objective function, and develop incentive mechanisms for encouraging appropriate levels (and mixes) of service quality. Plain old telephone service is far more complicated than typical models suggest, which requires that researchers rigorously analyze the costs and valuations of alternative quality improvements.

Seventeenth Annual Telecommunications
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Arlie House, Virginia

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The Measurement, Evaluation, and Encouragement of Telephone Service Quality

by Sanford V. Berg
and
John G. Lynch, Jr.

Research on quality of telecommunications service requires individuals with quantitative, historical, and analytical skills. Measuring quality and estimating its effects on costs and demands represent difficult tasks for engineers, econometricians, and psychologists. Similarly, understanding the institutional contexts within which choices have been made in the past requires a deep understanding of economics, politics, and history. In addition, while theoretical frameworks have identified how different market structures and regulatory constraints affect quality, the links to actual situations have not received much attention. The crucial relationships among empirical researchers, policy analysts, and economic theorists have been described most eloquently by J. von Neumann (1947) in the context of a mathematical discipline:

> . . . there is grave danger that the subject will develop along the line of least resistance, that the stream so far from its source will separate into a multitude of insignificant branches, and that the discipline will become a disorganized mass of details and complexities. In other words, at a great distance from its empirical source, or after much abstract inbreeding, a mathematical subject is in danger of degeneration. At the inception the style is usually classical; when it shows signs of becoming baroque, then the danger signal is up. (von Neumann, 1947, p. 147)

Quality of service research does not yet fit this characterization, but the topic is subject to abstract inbreeding. Theoretical work has enabled economists to isolate key implications of quality improvements, but there has been little success in finding empirical correlates for testing various models. Published quantitative research is nearly nonexistent for the pre-and post-divestiture telecommunications industry.[1]

The purpose of this paper is to provide an overview of the measurement, evaluation, and encouragement of telephone service quality. First, the paper surveys the theoretical literature exploring the production and valuation of quality. Then the various dimensions of local telephone service quality are identified. With so much data being collected, it is somewhat surprising to find so little analysis and interpretation of that data. Third, to improve the evaluation of service quality, we propose an approach which develops weights for different service dimensions. Finally, we consider practical ways to encourage appropriate levels of telephone quality. As the telecommunications industry undergoes regulatory and technological upheavals, the impact of service quality on costs and demands warrants additional analyses and evaluation.

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[1] Branch (1979) equates investments in equipment modernization with increased service quality. However, he attempts no independent measure of quality. Since two different modernization plans might be equally costly, but have different implications for consumer welfare, the link to quality valuation is essential. Similarly, Lawton's (1988) literature survey on telecommunications modernization includes a twenty-three page bibliography listing many studies of depreciation practices and cost allocation studies, but not a single citation on service quality.

1. THE THEORY OF SERVICE QUALITY

The inclusion of a quality variable enriches and complicates economic analysis. Since regulatory agencies monitor numerous dimensions of quality, collapsing these into a single index represents both a regulatory option and a theoretical necessity. Later we examine regulatory disadvantages to the adoption of pass-fail criteria for multiple service characteristics (such as signal clarity and dial tone response). Thus, regulators might choose to utilize a single index by creating a unique objective function which gives weights to different service quality dimensions. From the standpoint of economic research, simplification of the quality choice problem may be necessary just to make the analysis tractable. After reviewing previous analyses, we apply some of the key results to the regulatory situation in local telephone service.

1.1 Quality Choice with and without Regulation

Analysts have long been aware of regulatory problems arising from quality-of-service issues. For example, regulating price without obligating the firm to meet demand can lead to non-price rationing: one dimension of service quality deteriorates (as some customers are not served or reliability falls). Thus, additional choice variables tend to come under regulatory purview. In the mid-seventies, economists analyzed the basic issue of quality regulation in monopoly situations (Spence, 1975; Sheshinski, 1976; and Kihlstrom and Levhari, 1977). The following conclusions emerged from these studies.

(1) Monopoly power can affect quality choice under a number of circumstances: (a) if the level of output affects the cost of quality; (b) ..."if the good is used in variable proportions in firm or household production;" (c) "if some characteristic of the good facilitates...price discrimination;" (d) if "...the marginal valuation of quality depends on the quantity consumed." (Schmalensee, 1979, p. 193).

The first and fourth points are clear from the first order conditions for the monopoly and welfare maximizing firms. Marginal valuation (price) is a function of output (X) and dimensions of product quality (Z_1, Z_2)

$$P_x(X,Z_1,Z_2)<0;\ P_i(X,Z_1,Z_2)>0,\ i=1,2$$

Production costs depend on output and levels of product quality, where

$$C_x(X,Z_1,Z_2)>0$$

$$C_i(X,Z_1,Z_2)>0,\ i=1,2$$

Take the sum of producer and consumer surplus as the index of welfare

$$V(X,Z_1,Z_2) = \int_0^X P(V,Z_1,Z_2)dv - C(X,Z_1,Z_2)$$

Assuming an interior solution, the first order conditions equate marginal benefits with marginal costs for each choice variable:

$$V_x = P(X,Z_1,Z_2) - C_x = 0$$

$$V_i = \int_0^X P_i(V,Z_1,Z_2)dv - C_i = 0,\ i = 1,2$$

Quality is increased to where the valuation of additional quality improvements equals the additional cost of the quality improvement. Alternatively, the average valuation of quality improvement equals the cost per unit output of that improvement.

However, a monopolist bases decisions on marginal costs and marginal revenues: choices are based on the marginal revenue from quality improvements associated with the marginal consumer rather than the increase in valuations experienced by all the consumers. In the absence of perfect price discrimination, inframarginal consumers are not counted in the monopolist's maximization problem.

Analytically,

$$\pi(X,Z_1,Z_2) = P(X,Z_1,Z_2)\cdot X - C(X,Z_1,Z_2)$$

$$\pi_x = M(X,Z_1,Z_2) - C_x,\ \text{where } M(\ ) = P + P_x\cdot X$$

$$\pi_i = P_i(X,Z_i)X - C_i,\ i = 1,2$$

Both Spence and Sheshinski analyze this model for a single quality dimension, noting that two factors tend to lead to nonoptimal quality choice by an unregulated monopolist: nonseparability of quality and quantity in the cost function and dependence of marginal valuation of quality on the quantity consumed (on the demand side)

Early researchers emphasized the importance of how quality changes shifted the demand curve -- if improvements rotated demand outward from the initial price intercept, the size of the market may have increased (as when a new set of demanders enters the market, where the demanders have with marginal valuations comparable to those of initial consumers). Or, the initial demanders might just demand more units than before (at a given price). In each case

$$P_{xi}>0$$

The downward sloping demand function ($P_x<0$) is less steep at a given output level. In such situations, output and quality can be viewed as complements.

However, if quality improvements makes the demand curve steeper,

$$P_{xi}<0$$

the average valuation of quality will be greater than the marginal valuation, which tends to result in a monopolist supplying less than optimal level of quality.

Consider, for example, telephone access and usage as individual goods, each with different quality characteristics: dial tone delay for access can be reduced by improved switching capabilities; signal clarity, on the other hand, depends on the lines connecting users, including fiber optic facilities. Improved dial tone response probably does not expand the demand for access, making such quality improvements "substitutes" for increased output: the demand (marginal valuation) becomes steeper with quality improvements. On the other hand, signal clarity might be particularly important for business users, who can build their own communications networks if a high noise to signal ratio begins to interfere with voice or data transmissions. Thus, improved quality for usage can be viewed as a "complement" for increased output: demand rotates from the price intercept with quality improvements. Obviously, complex cross effects are possible, but this stylized characterization illustrates some of the complexities facing managers and regulators.

(2) Public service commissions have problems incorporating quality into the regulatory process, partly because quality is a public good if it must bundled with the basic service.

When a quality attribute is a "public good", its availability to one customer makes it available to all. Yet different customers will have different marginal valuations for the quality dimension. Both equity and efficiency may be enhanced if there is any way to distinguish among consumers, charging those who value the characteristic. Kihlstrom and Levhari (1977) modeled the efficiency conditions for quality as a public good. In some markets, the same service price is charged to all types of customers (whether or not the quality is valued as highly by a particular customer): such bundling can cause inefficiencies. For example, the bundling of access and usage implies that customers with different calling patterns will involve cross-subsidies: one customer paying for the costs incurred to increase quality for another. Here, the bundling of access and usage creates public good problems within a given customer class. The problem is no less severe for a single dimension of quality and different customer classes. Business demanders may have fundamentally different uses for communications channels than residential customers. For example, signal clarity and undisturbed connections are far more important for high speed data transmission than for conversation purposes.

These different valuations raise difficult problems for regulators. Pricing needs to reflect both the alternatives available to telephone subscribers and the costs imposed on the system when quality dimensions valued by a segment of subscribers are made available to all.

(3) Rate of return regulation can induce resource allocation improvements not only in terms of increased output, but also vis a vis quality choices; AJ distortions can also be exacerbated if quality is labor intensive.

Researchers have identified circumstances under which rate of return regulation (RORR) could enhance welfare. Spence showed that if quality were capital intensive, (and would otherwise be under-provided), RORR expanded the use of capital -- increasing both output and quality. Recall that quality should be raised if $P_{xi}<0$ for the monopolist. Note that the theory of rate base regulation suggests that a bias in quality improvements is possible.

Alternatively, price regulation which expanded output could have an impact on quality. Some of these stories involved leaving the quality choice completely up to the firm, but such a situation could yield a Cournot outcome (firms taking price as given and adjusting quality, and regulators taking quality as given and mandating a price). Both consumers (whose agents are the regulators) and the monopolist could be made better off under an alternative regime. Spence (1975, p. 424) suggests that this is one reason why quality standards should accompany price regulation.

Sherman and Visscher (1979) analyzed a wider range of rate designs than contained in the original Averch-Johnson formulation. They conclude:

> "The price structure problem is not confined to welfare losses caused by simple pricing inefficiencies of well-defined products or services, however. In some cases the right product or service characteristics may not even be priced, because a rate-of-return regulated firm will emphasize certain elements that might be priced and will deemphasize others." (p. 128-129).

Sherman and Visscher argue that, for example, the Civil Aeronautic Board's regulation of airlines pricing lead to a level of service quality that might have been inefficient (and the absence of different price/quality combinations). They emphasize that not only will the input mix (and technologies) be affected, but the output mix can be suboptimal--in terms of wrong qualities and inappropriate bundling of services. Thus, the definition and pricing of service characteristics become important aspects of the regulatory process which affect the decisions of the monopoly producer and consumers of the service.

(4) A multiproduct firm faces an additional set of quality choices, in which bundles are created to maximize profits subject to various regulatory constraints.

A recent contribution by Besanko, Donnenfeld and White (1988) showed how minimum quality standards, maximum price regulation, and rate of return regulation affect welfare. The basic model involves two groups of customers, one of which (type I) has a higher total and marginal willingness to pay than the other. Quality is observed but the heterogenous preferences for product quality cannot be observed. In the absence of perfect discrimination, the monopolist offers all customers two different price-quality combinations: self-selecting price quality bundles. By assuming a separable cost function for quality, BDW conclude that the monopolist offers group I the socially optimal quality, but the second group receives a suboptimal quality offering: "The magnitude of the distortion depends on the size of each group of consumers and the difference in each group's marginal willingness-to-pay for quality." (p. 414)

BDW find that minimum quality standards (MQS) and maximum price regulation (MPR) raise the quality offered to consumers who prefer low quality goods--reducing the distortion which characterizes monopoly price-quality choices. Their results illustrate how a multiproduct monopolist (such as a local cable company) might alter the price and channel offering mix for "basic" and "premium" services. MQS can correct the distortion facing type II customers. Alternatively, MPR which reduces the price to type I customers counteracts the unregulated monopolist's incentive to reduce the quality in the second bundle in order to raise the price for the first bundle. In the case of telephones, the definition of "basic service" becomes important -- since different dimensions of quality (party line vs. single line or size of area for non-toll calls) have different costs and capital intensities.

The impact of rate of return regulation (RORR) is much more complicated (even in their simple characterization of costs and valuations) because the production technology must be specified in greater detail. If quality is capital-intensive, the implicit reduction in effective cost of capital leads the RORR firm to choose more capital. "This in turn slackens the self-selection constraint and leads to an increase in quality for the low-quality good as well. Hence, the firm reacts to RORR by upgrading the entire quality schedule," (p. 424). If quality is capital intensive, RORR has mixed effects, since it increases quality offered to both groups. Consumers who prefer low quality goods are better off (the distortion is reduced) but consumers who prefer high quality goods face an increased distortion.

It should be noted that different demand or cost conditions would affect the BDW conclusions. Nevertheless, their analysis sheds light on the quality choices offered when self-selecting bundles of services are offered by firms. Are these "possibilities" important from the standpoint of determining the types of regulations most conducive to efficiency? Unless we step back from the mathematical details of these models, we may miss their relevance, or overemphasize something that ought not concern decision-makers. Empirical research is far from obtaining indications of inefficiencies. Nevertheless, the results which emerge from these models suggest that regulation (and deregulation) can yield perverse outcomes.

1.2 Implications when Quality is Multidimensional

Let us consider a simple case where two service characteristics are monitored by regulators: dial tone response (Z_1) and call completions (Z_2). The Florida Public Service Commission has a rule that 95% of all calls shall receive a dial tone within 3 seconds. The surveillance methods for determining compliance are problematic (peak hours? as a proportion of all calls?)[2] However, even after appropriate monitoring procedures have been adopted, determining the benefits and costs of exceeding the standard is complicated. For a second dimension of quality, intra-office call completions, 95% of all calls to numbers with the same first 3 digits as the caller must be completed.

We will assume that regulators attempt to maximize welfare, subject to the telephone company's budget constraint (total revenues are no less than total costs). Alternatively, regulators may be engaging in satisficing behavior, but we will assume welfare maximization. Spence (1975) pointed to the specification of minimum quality standards in the context of price regulation, arguing that it could stem from underprovision of quality in that situation. His and Sheshinski's analyses are further reinforced in a multiquality context by Besanko, Donnenfeld and White (1988). If regulators do not encourage a telco to exceed the stated standard, they must believe that marginal benefits are equal to the marginal costs when the standards are just met.

This condition for optimality is depicted in Figure 1, where $Z_1 = .95$ and $Z_2 = .95$ in equilibrium (point E). Note that output is adjusted for the different production possibility frontiers shown in the Figure (so that $P = MC$). The perceived levels of benefits are also shown (again, measured in dollar terms). Point A (94,94) involves resource costs of $100: additional costs of $10 yield equal additional benefits (at point E). However, beyond E, further improvements in quality cost more than they are worth. Thus, if the marginal cost of additional output is just equal to the marginal valuation (price) of that output, the marginal efficiency conditions are satisfied.

The above is an extremely simplified characterization of the opportunity set and relative valuations of quality. First, we are implicitly assuming separability in production, so that the cost of additional output is independent of the levels of both quality attributes. In addition, since the shift from A to E implies higher quality overall, the marginal valuation for output will be greater at E, if output is not increased. So we must let output expand to the point where price equals marginal production cost. If marginal production cost is constant, price will not change. Anyone familiar with single quality, single output models is aware of how complicated the analysis becomes if there are cost interdependencies (as when higher Z_1 affects marginal production costs).

If point E (95,95) is optimal today, need it remain so in the future? Even if preferences remain unchanged, income elasticities for output and quality, changing customer mixes, and technological changes will tend to yield a new optimal point. For example, if the cost of shifting from E to B is $8 rather than the $20 shown in the figure, then regulators should encourage further quality improvement. However, if the benefit is primarily via inframarginal consumers, a profit-maximizing firm subject to price control will not have an incentive to enhance quality. Either the regulators will have to mandate new minimum quality standards, or quality incentives must be established--rewarding

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[2] Another issue is whether 90% receiving a dial tone within 2 seconds might be preferable to 95% within 3 seconds, but since the former probably implies greater than 95% in 3 seconds, we take the duration of the delay as given.

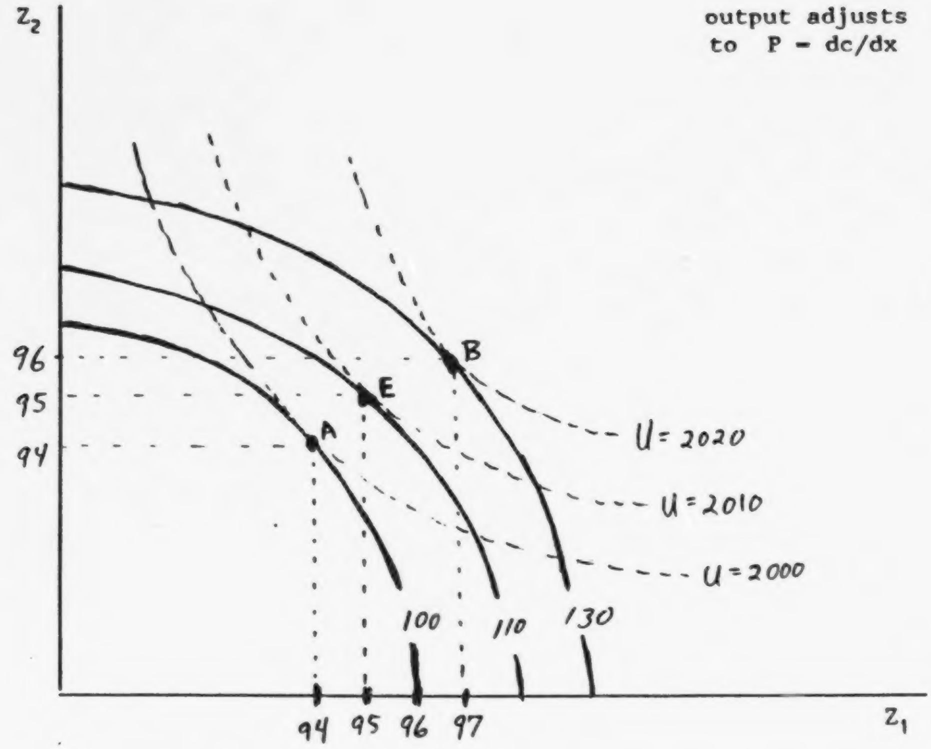


Figure 1

Welfare Maximization for Two Quality Attributes telcos which achieve higher standards.

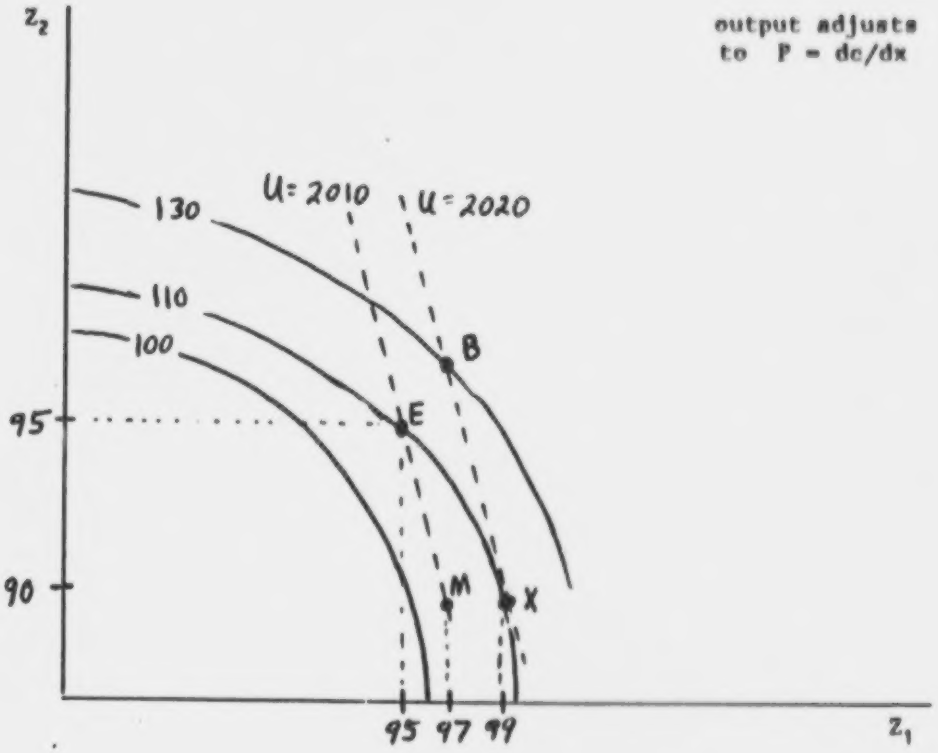
Clearly, the regulatory information requirements become burdensome: commission staffs must become familiar with the underlying production technologies and cost structures. In addition, they must know the preferences of consumers, and capture those preferences in some objective function relating higher levels of quality to dollar benefits. Given the dramatic technological changes in this industry (and state employee staffing problems), the knowledge of changing cost trade-offs is unlikely to reside in state regulatory commissions. Furthermore, if the "correct" benefit levels for the three indifference curves were 2000, 2005, and 2007, the commission ought to be loosening, rather than tightening, minimum quality standards (moving from E to A).

Figure 2 illustrates the issue we focus on in this study. At point E, the marginal rate of substitution (MRS) between Z_1 and Z_2 does not equal the marginal rate of transformation (as reflected in the slope of the production possibility frontier). For simplicity, we assume constant MRS. Compared with the preferences depicted in Figure 1, at point E, the relative valuation of Z_1 is greater in Figure 2. The MRS is roughly minus one in Figure 1, indicating that (95.5, 94.5) is valued about equally with (94.5, 95.5). However, in Figure 2, the former is preferred to the latter: additional Z_1 is valued relatively more than additional Z_2. The MRS depicted in Figure 2 is -2.5. So if $Z_1 = 96$, Z_2 could fall to 92.5 to obtain the same benefit as point E.

The conclusion is elementary: for the same resource cost ($110), higher benefits would be obtained at point X, than are obtained at point E. How can a regulatory incentive system encourage a telco to modify its quality mix: increasing quality for dimensions which are relatively more highly valued? The following sections describe a methodology for determining weights for the various dimensions of telephone service quality. Firms are then presented with the regulatory objective function--and allowed to trade-off high cost (low valued) quality dimensions for low cost (highly valued) quality dimensions. In the context of the simple example, if (95, 95) yielded an "acceptable" overall level of quality, then the firm would be able to achieve the same quality score with lower costs: at point M (97, 90). One scoring function which would signal the telco to modify its quality mix would be $Q = Z_2 + (5/2)Z_1$, and the minimum quality "score" is $Q = 665$.

The telco has lower costs at M but has a score of 665 (based on the formula. Alternatively, a higher quality standard (score) could be set, driving the firm to point X--so customers achieve greater satisfaction without an increase in outlays on quality. However, recall that the increase in demand will require an expansion of output, and corresponding marginal production costs could change.

The main point is that a more comprehensive treatment of quality by regulators could yield benefits to customers, with some of the savings providing an incentive to firms. The associated measurement problems are not simple: aggregating quality characteristics to calculate a single "score" requires some confidence in the value elicitation process, and determining the appropriate "score" requires an understanding of the changing technological opportunities.



z_2
output adjusts to P = dc/dx
U=2010
U=2020
130
110
100
B
E
95
90
M
X
95
97
99
z_1

Figure 2

New Relative Valuations of Quality Attributes

In addition, telcos face different costs (urban-rural differences and different historical patterns of investment--yielding different technological opportunities). Different customer mixes (or different income levels for those customers) may also imply different relative valuations for the various quality dimensions (and for additional output, compared with improved quality scores). However, on this latter point, we find in our empirical work remarkable agreement among experts at different telephone companies regarding the relative importance of different quality dimensions. We now turn to that work.

2. MEASUREMENT OF SERVICE QUALITY

2.1 Dimensions of Service Quality

The Florida Public Service Commission evaluates local telephone companies on the basis of dial tone delay, meeting telephone installation appointments and thirty-six other performance standards. Companies measure various technical characteristics and maintain detailed records of company performance. Although these rules (or standards) can be further grouped into nine clusters, creating a single index of quality is not a simple task. The National Association of Regulatory Utility Commissioners recommends a similar set of standards.[3] However, the weights to be given individual rules have not been established.

In a sense, the absence of a reasonable weighing scheme means that service quality for a particular dimension could be too high--given the incremental costs and benefits of moving from, say 94% to 95% for a particular standard. Alternatively, exceeding present standards for some dimensions of quality might yield substantial additional consumer benefits relative to the incremental costs of surpassing the standard. Given the billions of dollars associated with maintaining service quality standards nationwide, it is important that analysts identify ways to deal with quality in a more systematic and rigorous fashion.

A complete listing of the thirty-eight FPSC quality standards is shown in Table 1. The nine broad categories (clusters) are (1) dial tone delay, (2) call completions, (3) answer time (eg. for operators, directory assistance, repairs, or business office), (4) directory service, (5) intercept services (eg. changed numbers, vacation disconnects), (6) availability of service (three day primary service and meeting appointments), (7) 911 service, (8) repair service (eg. 24 hour restoral), and (9) public telephone services (involving sixteen separate components). Clearly, aggregating these different categories into a single quality index is no simple process.

There are a number of other ways quality of service might be determined. Consumers could be surveyed directly regarding quality of service. For example,

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[3] Telephone utilities have done some work in the area. For example, the book *Engineering and Operations in the Bell System* (R.F. Rey, editor, 1983) from Bell Laboratories describes processes for evaluating service and company performance. The analysts note that complex network interfaces occurring at company boundaries create new problems for performance evaluation (p. 683-84). The absence of references to regulatory standards is an interesting omission from this comprehensive source-book, since these standards are supposed to be used to evaluate performance.

Table 1
38 PSC RULES WITH PUBLISHED STANDARDS OF PERFORMANCE

Rule Cluster 1: Dial Tone Delay

1. Dial Tone Delay: 95% of all calls shall receive a dial tone within 3 seconds.

Rule Cluster 2: Call Completions

2. Intra-office: 95% of all calls to numbers with the same first 3 digits as your own shall be completed.
3. Inter-office: 95% of all calls to numbers with different 3-digit codes but within your home exchange shall be completed.
4. EAS: 95% of all calls to different home exchanges must be completed.
5. Intra-company DDD: 95% of all toll calls within your local company's service area shall be completed.

Rule Cluster 3: Answer Time

6. Operator Answer Time: 90% of all toll calls to a toll office shall be answered within ten seconds after the start of an audible ring.
7. Directory Assistance: 90% of all calls to Directory Assistance shall be answered within twenty seconds after the start of an audible ring.
8. Repair Service: 90% of all calls to Repair Service shall be answered within 20 seconds after the start of an audible ring.
9. Business Office: 80% of all calls to Business Offices shall be answered within 20 seconds after the start of an audible ring.

Rule Cluster 4: Adequacy of Directory and Directory Assistance

10. Directory Service: A directory conforming to PSC rule 25-4.040 shall be published within 12-15 months since the last published directory.
11. New Numbers: 100% of all new or changed listings shall be provided to directory assistance operators within forty-eight hours after connection of service, excluding Saturdays, Sundays, and holidays.

Rule Cluster 5: Adequacy of Intercept Services

12. Changed Numbers: 90% of all calls to numbers that have been changed shall be answered automatically within 20 seconds.
13. Disconnected Service: 100% of all calls to numbers to disconnected numbers shall be answered within 20 seconds by a recording informing the caller that the number reached is not in service.
14. Vacation Disconnects: 80% of all calls to numbers temporarily disconnected at the customer's request shall be answered within 20 seconds.
15. Vacant Numbers: 100% of all calls to vacant numbers shall be answered within 20 seconds by a recording informing the caller that the number reached is not in service.
16. Disconnects Non-Pay: 100% of all calls to numbers disconnected due to non-payment shall be answered within 20 seconds by a recording informing the caller that the number is not in service.

Rule Cluster 6: Availability of Service

17. 3-Day Primary Service: 90% of requests for Primary Service in any Calendar month shall normally be satisfied within an interval of three working days after the receipt of application.
18. Appointments: 95% of appointments kept that are set within time frames of 7-12 A.M., 12-5 P.M., or 5-9 P.M., or for a specific hour of the day.

Rule Cluster 7: 911 Service

19. 911 Service: 95% of all calls to 911 Service answered within 10 seconds.

Rule Cluster 8: Repair Service

20. 24 Hour Restoral: 95% of all customers shall have service restored within 24 hours of reporting trouble.
21. Appointments: 95% of Repair Service appointments kept that are set within time frames of 7-12 A.M., 12-5 P.M., or 5-9 P.M., or for a specific hour of the day.
22. Rebates -- Over 24 Hours: 100% of customers whose service is interrupted for more than 24 hours shall be given pro-rated rebates.

Rule Cluster 9: Public Telephone Service

Sub-Cluster 9a: Functioning of Public Telephones

23. Serviceability: 100% of public telephones must meet all service standards applicable to service to other customers.
24. Telephone Numbers: 100% of all public coin phones must have identified station telephone numbers.
25. Receive Calls: 100% of all pay phones -- except in prisons, schools, and hospitals -- must be able to receive incoming calls.
26. Dial Instructions: 100% of all public telephone stations should have legible and clear dialing instructions, including notice of the lack of availability of local or toll service.

Sub-Cluster 9b: Enclosure of Public Telephones

27. Accessibility to Handicapped: 100% of all stations installed since January 1, 1987 must be accessible to the handicapped.
28. Cleanliness: Normal maintenance shall include inspection and reasonable effort shall be taken to insure cleanliness and freedom from obstructions of 95% of all coin stations.
29. Lights: 100% of all public telephones must be lighted during hours of darkness when light from other sources is inadequate to read instructions and to use the instrument.

Sub-Cluster 9c: Coin Operations of Public Telephones

30. Pre-Pay: 100% of all coin-operated public telephones allow Pre-Pay. They provide a dial tone, require coin deposit prior to dialing (except for calls to operator or 911 as discussed 32 and 33 below), and automatically return any deposited amount for calls not completed.
31. Coin Return: 100% of all coin stations shall return any deposited amount if a call is not completed, except messages to a Feature Group A access number.
32. Coin Free Access - Operator: 100% of all public telephones shall have coin free access to the Operator.
33. Coin Free Access - 911: 100% of all public telephones shall have coin free access to 911 Service.
34. Coin Free Access - Directory Assistance: 100% of all coin stations shall allow coin free access

or coin return access to Local Directory Assistance.

35. Coin Free Access - Repair Service: 100% of all coin stations shall allow coin free access or coin return access to Repair Service.

36. Coin Free Access - Business Office: 100% of all coin stations shall allow coin free access or coin return access to the Business Office.

Cluster 9: Public Telephone Service (Continued)

Sub-Cluster 9d: Directory Security of Public Telephones

37. Directory Security: 100% of all coin stations have directories available. When there are three or more coin stations in one area, there must be a directory for the local calling area for every two stations. Otherwise, there must be a directory for every station.

Sub-Cluster 9e: Address/Location of Public Telephones

38. Address/Location: 100% of all public telephones have their locations posted, and the identifications of locations coordinated with the appropriate 911 or emergency center.

a National Regulatory Research Institute Report (Mount-Campbell et al., 1978) provides a survey design for obtaining opinions from telephone subscribers. Trends in consumer perceptions can be captured via such surveys. In addition, customer complaints made directly to the utility or to the FPSC provide another index of the acceptability of quality service levels (see Appendix A which lists types and numbers of complaints in Florida, 1987). However, customer-initiated evaluations can be spurred by other factors--an on-going rate case, a spate of consumer activism, or developments beyond a firm's control (as with AT&T divestiture causing customer confusion during the transition period).

As a supplement to such data, trends in the nine clusters (or thirty-eight categories) provide an indication of the technical aspects of telephone service. However, too many sub-indices makes any overall external evaluation unmanageable. Firms do not have a simple task in determining their own quality of service. See, for example, Militzer (1980) who describes AT&T's internal evaluation process in some detail. Note that AT&T distinguishes between service measurements (reflecting operations characteristics perceivable to customers) and performance measurements (reflecting whether corporate technical objectives are being met). A key question is what weights should be given the various rules or standards.

The most significant published source on the measurement of service quality is a recent volume edited by B. Cole (in press), containing papers by state and national regulators and telecommunications specialists. Kraushaar's and Curry's papers in this volume survey the effect of the Bell System breakup on service quality. They tentatively conclude that quality has not declined following the breakup, and may even have increased. However, they point to potential problems, including the lack of comparable technical measures across regulatory jurisdictions and over time. In addition, the absence of an overall index of quality hampers the performance evaluation process.

2.2 Customer vs. Expert-Based Measurement

The welfare-maximizing PSC is actually interested in using an evaluation scheme that reflects customers' preference weights. Given this, researchers could ask the concerned parties (i.e. consumers) to identify current quality and to make trade-offs between levels of performance on the different rules. The alternative to asking consumers is to ask experts who possess the technical knowledge necessary to make trade-offs between rules. This study used experts within the FPSC and telcos, but it was stressed to respondents that their answers should reflect the consumers' interests. This amounts to modeling the experts' perceptions of what is most important to consumers. Although the experts' perceptions may be inaccurate, this approach was deemed a reasonable solution to the problem. In addition, a telecommunications engineer is more likely to be aware of the consequences of changes in these variables on system performance. In particular, interdependencies among rules would be understood by the technically trained individual.

We have argued elsewhere (Buzas, Lynch, and Berg, forthcoming) that, despite their relevance, customer-based measures of importance cannot be treated as the ultimate criterion for several reasons:

(1) Consumers may lack the technical expertise necessary to evaluate certain dimensions. In some cases, they simply may not understand the technical terminology (e.g. Call Completions Intra-office, Inter-office, EAS and Intra-company DDD). Other dimensions may be "credence" attributes (Darby and Karni 1973), the values of which cannot be determined even after experiencing their levels.

(2) Due to the monopolistic nature of the industry, consumers do not have the opportunity to experience service from firms providing different profiles of strengths and weaknesses across the various dimensions. Thus, they lack the covariation information necessary to abstract the values of the dimensions -- as in Meyer's (1987) analysis of the process by which consumers learn multi-attribute preferences.

(3) Because customers have not had to make choices among competing services, they have not had occasion to think about the tradeoffs between different dimensions. Research has shown that when prior opinions about tradeoffs do not exist, revealed weights are highly unstable and susceptible to minor changes in the elicitation procedures (Feldman and Lynch 1988; Fischhoff, Slovic and Lichtenstein 1980).

3. EVALUATION OF SERVICE QUALITY

3.1 Weights for Dimensions and Customer Classes

The dominant approach to monitoring quality in regulated monopolies is to set performance standards on various objective and technical dimensions of service quality (e.g., Model Telecommunications Service Rules, National Association of Regulatory Utility Commissioners 1987). The critical feature of regulation by standard is that essentially continuous variations in performance on any dimension are degraded into a two-category (pass/fail) classification (Fischhoff 1984).

In the competitive marketplace, firms offer price-quality combinations and potential consumers choose the bundles that maximize their net benefits. Even though identifying the level of quality is not a simple process, consumers generally "know what they like", and the resulting pattern of demand and market shares is often viewed as meeting some optimality criteria. However, for public utilities, mandated entry barriers or the direct regulation of technical features of the service cut short the evolutionary process arising from competitive markets. The question then, is how to evaluate quality in the context of a regulated industry, like local telephone service.

3.2 The Approach Selected: Hierarchical Conjoint Analysis

In order to design an experimental set of profiles capable of estimating the parameters of expert regulators' objective functions, it was first necessary to determine the general form of $\hat{Q} = f(x_1, x_2, \ldots, x_{38})$. Nine telecommunications experts at the Florida Public Service Commission completed a series of pretests designed to determine 1) whether the various technical dimensions combined additively or configurally to determine judgments of overall service quality, and 2) whether the partial effect of each dimension on overall judgments was linear or curvilinear. The pretests employed "functional measurement" methodology (Anderson 1982; Lynch 1985).

Experts were asked to judge the quality of service provided by a series of hypothetical companies by pairs of the 38 technical dimensions. Stimuli were defined by a series of two-factor repeated measures designs. In each design, the two dimensions each varied over four levels. If historical data showed observations both above and below the standard for a given dimension, we chose high and low levels of that dimension in accord with the historical range. For several dimensions, though, no company had ever failed to pass the standard. For these dimensions, we chose the lowest level in pretests to be 1% or 2% below the standard.

Additive or Multiplicative

We first tested whether pairs of dimensions combined additively or configurally to affect experts judgments of quality. We considered it possible that experts' might combine the 38 dimensions in accord with a conjunctive decision rule, whereby a company would be judged acceptable if it passed all standards, but would be judged unacceptable if it failed even one standard (Einhorn 1971; Fischhoff 1984). Alternatively, a few dimensions might be judged to be so important that failing standards on these dimensions might cause other dimensions to be ignored, and an unacceptable overall rating to be assigned. Other configural objective functions considered plausible *a priori* were multiplicative and multilinear rules (Keeney and Raiffa 1976) and averaging rules that give disproportionate weight to negative information (Anderson 1974; Lynch 1979). The absence of significant interactions between dimensions ruled out all of these configural rules, implying that an additive combination rule was appropriate. This conclusion was supported both by group level tests and analyses of individual level data.

Linear or Nonlinear

Next we turned to analyses intended to determine whether the effect of each cue on overall quality were linear or nonlinear. Since each rule has a published standard for performance, it was possible that experts *dichotomized* performance into two levels: Pass or Fail. This would imply for example, that for the intra-office call completions standard cited above, a score of 94% would be just as bad as one of 80%, since both are below the standard. Similarly, a score of 96% would be just as good as one of 100%. We tested for nonlinearities of this form or of alternative forms by ANOVA tests of whether the main effects of each attribute in the two factor designs exhibited any significant deviation from the linear relationships. Results showed no significant residual from linearity within the ranges considered. A one percentage point change in performance on a given dimension caused the same degree of improvement in overall evaluation, regardless of whether improvement was from 80% to 81% or from 99% to 100%. Moreover, this was approximately true even when the change caused the company to move from not meeting the standard to meeting it exactly.

Functional Form

Taken together, these pretests implied that experts' overall quality judgments could be appropriately modeled by a weighted linear composite equivalent to equation 1:

$$(1) \quad \hat{Q}_j = a + w_1 * (x_{j1} - x_{1*}) + w_2 * (x_{j2} - x_{2*}) + \ldots + w_{38} * (x_{j38} - x_{38*}),$$

where a is a constant, w_i is the weight for the i-th criterion, and $x_{ji} - x_{i*}$ is the deviation of the j-th company's performance from the standard on the i-th criterion.

Hierarchical conjoint analysis was developed to circumvent problems with two more commonly used variants of conjoint analysis (Louviere 1984; Louviere and Gaeth 1987). In this approach, a large number of dimensions are broken down into hierarchical "clusters", and profiles are judged that are described only on the dimensions included in that cluster. Each cluster includes only a small number of related dimensions, so that respondents do not have to integrate an overwhelming amount of information at any one time. In the present context, these "rule clusters" were: Dial Tone Delay (1 dimension); Call Completions (4 rules); Answer Time (4 rules); Adequacy of Directory and Directory Assistance (2 rules); Adequacy of Intercept Services (5 rules); Availability of Service (2 rules); 911 Service (1 rule); Repair Service (3 rules); and Public Telephone Service (16 rules). Because the Public Telephone Service cluster included so many dimensions, it was further broken down into 5 "sub-clusters", as described in Table 1.

Determining the weights involved three steps. First, we calculated the weights of a one percentage point change in compliance on the evaluation of performance within each cluster of rules (Table 1). Experts rated different combinations of performance levels within each cluster of rules on a scale from 1 to 10. There were 13 questionnaires of this type - one for each cluster of rules. For example, in the questionnaire for Answer Time, subjects judged 8 profiles formed by a 1/2 fractional factorial design (Winer 1973), in which the four factors varied over the following levels: Operator Answer Time, 89% and 100%; Directory Assistance, 89% and 99%; Repair Service Answer Time, 75% and 98%; and Business Office, 67% and 100% (Winer 1973). Based on these ratings, we calculated the weights of a one percentage point change on the evaluation of performance for the cluster of rules. In general, the evaluation of the j-th company for the k-th rule cluster of i rules is given by $y_{jk} = g_k(x_{j1(k)}, x_{j2(k)}, \ldots, x_{ji(k)})$. In the present application, pretesting determined that the function was linear in form.

Second, we determined the relative importance of the clusters of rules. Experts were asked to rate combinations of evaluations of performance on the clusters on a scale from 1 to 10. That is, they were shown profiles formed by a fractional factorial design, in which factors varied over levels of cluster evaluations, such as 1 and 10 for Answer Time and 2 and 10 for Intercept Services. There were two questionnaires of this type. One related performance on the five Public Telephone sub-clusters to overall performance on Public Telephone Service (see Table 1). The other related performance on the 9 rule clusters to the evaluation of overall service quality. Based on these ratings, we next calculated the weights of a one percentage point change in cluster evaluation on the overall evaluation. The tradeoffs between performances on the K clusters were given by $\hat{Q}_j = h(y_{j1}, y_{j2}, \ldots, y_{jK})$.

Lastly, we calculated the weight a one percentage point change in performance on overall evaluation using the weights of a one percentage point change on cluster evaluation and the weights of a point change in cluster evaluation, i.e. $\hat{Q}_j = f(x_{j1}, x_{j2}, \ldots, x_{j38}) = h(y_{j1}, y_{j2}, \ldots, y_{jK}) = h[g_1(x_{j1(1)}, x_{j2(1)}, \ldots, x_{ji(1)}), g_2(x_{j1(2)}, x_{j2(2)}, \ldots, x_{ji(2)}), g_K(x_{j1(I)}, x_{j2(I)}, \ldots, x_{ji(K)})]$. Since the functions h and g were linear, this involved multiplying the weights from the first and second steps above.

Application to a Hypothetical Company

Exhibit 1 shows the company score and rule for 38 dimensions of telephone service quality. For each percentage point above the "rule," additional points are earned by the company -- depending on the weight accorded to the particular dimension: greatly exceeding a low-valued dimension is less valuable than slightly exceeding the most highly valued dimension.

In the example, an overall score of 8.21 is achieved, compared with a 6.10 for just matching each current FPSC rule. How to interpret this in practice remains up to the Commission and its staff. But the single score approach has a number of favorable features.

4. ENCOURAGEMENT OF SERVICE QUALITY

Although the actual use of service quality data in the regulatory process has not been examined by analysts, the topic is clearly important. Our own contribution attempts to identify a single service quality index which could be used to rank firms and to reward those with superior performance over time. Since the competitive marketplace is unavailable to signal preferred price-quality bundles, regulators must simulate such a process. Note that the role of service quality is reduced if regulators create so many dimensions of quality that comparisons become cumbersome, if not impossible. Thus, current practice of specifying minimum performance standards has severe limitations. An index giving weights to each standard would assist both firms and regulators.

4.1 Perverse Incentives of Pass/Fail Standards

Technical standards themselves are clear and precise, but two major classes of problems arise in their use to monitor and reward quality. First, by evaluating performance relative to a pass/fail cutoff, distinctions among various levels of sub-standard and super-standard performance are ignored. As a consequence, companies are given targets to achieve, but little incentive to

EXHIBIT 1

EXAMPLE OF COMPREHENSIVE EVALUATION FOR HYPOTHETICAL COMPANY

CRITERIA	(A) COMPANY SCORE	(B) RULE	(C) (A-B)	(D) WEIGHT OF 1% CHANGE	(CXD) GAIN OR LOSS
1) Dial Tone Delay	100%	95%	+ 5.0	.097	+0.4850
2) Call Completions					
Intra-Office	99.9%	95%	+ 4.9	.087	+0.4753
Inter-Office	99.2%	95%	+ 4.2	.084	+0.3528
EAS	99.9%	95%	+ 4.9	.058	+0.2842
Inter-Company-DDD	96.8%	92%	+ 4.8	.041	+0.1968
3) Answer Time					
Operator	95.7%	90%	+ 5.7	.012	+0.0684
Directory Assistance	96.3%	90%	+ 6.3	.005	+0.0315
Repair Service	79.1%	90%	-10.9	.008	-0.0872
Business Office	66.3%	80%	-13.7	.004	-0.0548
4) Directory					
Directory	100%	100%	0.0	.058	0.0
New Numbers	94.9%	100%	- 5.1	.014	-.0714
5) Intercept Services					
Changed Numbers	100%	90%	+10.0	.008	+0.0800
Disconnected	100%	100%	0.0	.015	0.0
Vacation Disconnects		80%	0.0*	.002	0.0*
Vacant Numbers	100%	100%	0.0	.009	0.0
Non-Pay		100%	0.0*	.016	0.0*
6) Availability of Service					
3-Day Primary Service	100%	90%	+10.0	.030	+0.3000
Appointments	100%	95%	+ 5.0	.046	+0.2300
7) 911 Service		95%	0.0	.117	0.0
8) Repair Service					
24-Hour Restoral	94.1%	95%	- 0.9	.018	-0.0162
Appointments	94.4%	95%	- 0.6	.023	-0.0138
Rebates	78.6%	100%	-21.4	.003	-0.0642
9a) Functioning of Public Telephones					
Servicability	97.8%	100%	- 2.2	.027	-0.0594
Telephone Numbers	100%	100%	0.0	.015	0.0
Receives Calls	100%	100%	0.0	.013	0.0
Dial Instructions	100%	100%	0.0	.022	0.0
9b) Enclosure of Public Telephones					
Handicapped	100%	100%	0.0	.003	0.0
Cleanliness	100%	95%	+ 5.0	.002	+0.0100
Lights	96.8%	100%	- 3.2	.004	-0.0128

EXHIBIT 1 (cont'd)

CRITERIA	(A) COMPANY SCORE	(B) RULE	(C) (A-B)	(D) WEIGHT OF 1% CHANGE	(C)X(D) CXD GAIN OR LOSS
9c) Coin Operations					
Pre-Pay	100%	100%	0.0	.009	0.0
Coin Return	98.6%	100%	- 1.4	.005	-0.0070
Coin Free Access Operator	NA	100%	0.0*	.002	0.0*
Coin Free - 911	100%	100%	0.0	.003	0.0
Coin Free Directory	100%	100%	0.0	.001	0.0
Coin Free Repair	98.9%	100%	- 1.9	.001	-0.0019
Coin Free Business	99.6%	100%	- 0.4	.001	-0.0004
9d) Directory Security	97.1%	100%	- 2.9	.002	-0.0058
9e) Address/Location	99.6%	100%	- 0.4	.017	-0.0068

Overall Evaluation = Base (6.1000) + 0.4850 + 0.4753

+ ... -.0058 - 0.0068

= 8.2123

exceed these targets. If standards were set by formal economic analysis at the point where the marginal benefits of improvements were equated to the marginal costs along each dimension, meeting the standards exactly would enhance consumer welfare. In practice, though, the levels of standards often arise from a chaotic set of political and social forces (Fischhoff 1984). Moreover, even when standards are set initially at levels that equate marginal benefits and costs, technological change makes it likely that exceeding present standards for some dimensions might yield substantial additional consumer benefits relative to the current incremental costs of surpassing the standards. In these cases, the typical cutoff-based system may dysfunctionally fail to reward superior performance.

The proposed system overcomes perverse incentives that seem to be present with the current system. In particular, companies previously had no regulatory incentive to exceed standards on any dimension, even if that dimension was one where improvements could be realized at low cost, and where a small improvement would lead to a sizeable consumer welfare gain. Thus the prevailing system provides no incentive to respond to new technological opportunities. The proposed system should lead a company to act in ways that enhance both its own self-interest and the interests of consumers. The system provides incentives to improve on those dimensions where a) gains to the overall comprehensive score -- and presumably to consumer welfare -- are greatest, b) and where those gains can be achieved at the lowest possible cost to a company.

4.2 Specification of an Objective Function

The second major problem regulators face is how to combine information on multiple dimensions of service quality into an overall assessment. In Florida as in other states, this has been left to the discretion of the regulators, who must integrate complex information on a very large number of dimensions using unaided (intuitive) judgment. The exact nature of the objective function is left unspecified.

Even expert regulators face an unenviable task as they attempt to combine intuitively information on the many dimensions along which telephone companies are evaluated. Research in behavioral decision making across a wide variety of tasks has demonstrated convincingly a syndrome of dysfunctional consequences when decision makers experience information overload. Ironically, the decision makers themselves are largely oblivious to these consequences. Indeed, their confidence in their judgments about an object increases as they have more information about the object (Payne 1982), even when the added information is normatively irrelevant (Ronis and Yates 1987).

The large number of rules on which regulators have information may cause them to "manage by exception." By focusing on the rules that a company fails, regulators essentially ignore dimensions on which the company being evaluated has exceeded the standards. If the marginal benefits of improvement are greater for the latter (passed) than for the former (failed) dimensions, it follows that by "managing by exception," regulators create incentives for resource misallocation by companies.

4.3 Concluding Observations

Identifying relative trade-offs among different dimensions of quality is just a first step in a comprehensive research agenda. How are relative costs affected by changes in the different dimensions of quality? Engineering studies ought to allow us to identify marginal costs, although some inputs are likely to affect multiple quality dimensions -- leading to some difficulties in disentangling the impacts of shared inputs.

No less difficult is the demand side of the equation. How does the marginal valuation of quality depend on the quantity consumed? Would society prefer quality improvements or higher rates of telephone penetration? Which types of quality are substitutes and which are complements for output? And what is the relevant output, access or usage? Furthermore, when the parent of regulated firm has unregulated subsidiaries, quality enhancements of the regulated service may have implications for the demand (or costs) of outputs produced by unregulated subsidiaries. Such interdependencies might be as simple as the creation of goodwill (via advertising or outstanding service) or as complicated as the design of interface protocols. We have a long way to go before sophisticated theory is able to assist regulators in establishing multiple standards and/or a single weighted score which will signal the correct level and mix of qualities.

Measurement without theory or theory without measurement: both situations leave decision-makers without a basis for choosing from among a wide variety of output-quality combinations. When there were no competitive offerings, the absence of a consistent view of price quality trade-offs probably lead to inefficiencies and inequities. However, the potential costs of mistakes by firms and oversight groups today is enormous. At present, economists are only beginning to scratch the surface of a very complicated set of issues. The approach suggested here is no panacea, but hopefully the conjoint analysis will stimulate creative ways to measure, evaluate, and encourage quality in telecommunications.

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Appendix A

Customer Initiated Complaints

The Division of Consumer Affairs of the FPSC receives, investigates, and resolves consumer complaints regarding gas, electricity, water, and telephone utilities. Since it received 44,189 complaints during 1988, but recorded and investigated only 5,857 cases, significant screening occurs at the FPSC. For example, a complaint about high prices would not be logged in, but service problems would be "counted" and studied. The Division presents testimony on complaint activity during rate hearings. References to poor service are sometimes made in published decisions.

Commissioners also hear testimony on the technical standards from the Division of Communications. To measure the level of service provided by telecommunications firms, over half a million test calls were made in the service territories of the major local operating companies. These were used to measure all completions, dial tone delay, and other performance characteristics of the local system. The staff also evaluated such items as answer time, installation intervals, directory assistance and billing accuracy. Thus data on the 38 characteristics described are also introduced during the regulatory hearing process.

The attached listing shows the complaints logged in during 1988, indicates whether they were justified, and provides bottom line indices: percent change from the previous year and the number of justified complaints per 1,000 customers. Such information represents a potentially useful data base -- as consumer perceptions regarding quality of service could be linked to telco outlays in particular areas. So far as we know, this issue has not been addressed in the past, so it represents a potentially promising research avenue.

TELEPHONE INDUSTRY COMPLAINTS 1988

	COMPLAINTS LOGGED IN 1988				COMPLAINTS CLOSED IN 1988			
					Justification			Percent
	Service	Billing	Total	Major Type	Yes	No	Some	Justified
Alltel	45	13	58	Serice Problems	26	16	17	44%
Centel	123	49	172	Delay Connect	82	44	44	48%
Florala	5	0	5	Party Line	2	0	2	50%
GTE	399	137	536	Service Problems	211	196	133	39%
Indiantown	2	0	2	Service Problems	0	2	0	0%
Long Distance	170	836	1006	Alt. Operator Service	624	194	175	63%
N.E. Florida	6	3	9	Delay Connect	2	7	1	20%
Pay Telephone	93	41	134	Service Standards	70	25	24	59%
Quincy	2	3	5	Service Problems	0	3	1	0%
St. Joseph	10	4	14	Service Problems	5	7	3	33%
Southern Bell	1318	451	1769	Delay Connect	688	577	477	40%
Southland	1	9	1	Service Problems	1	0	0	100%
United	158	88	246	Delay Connect	59	93	79	26%
Vista-United	0	2	2	Miscellaneous Billing	0	1	0	0%
Industry Total	2332	1627	3959	Delay Connect	1770	1165	956	45%

TELEPHONE INDUSTRY COMPLAINTS 1988
Continued

	1988			
	Total Received	Percent Change From '87	Complaints Per 1000 Customers	Justified Per 1000 Customers
Alltel	58	-23%	1.281	0.618
Centel	172	-29%	0.773	0.373
Florala	5	-38%	3.183	1.273
GTE	536	-26%	0.353	0.141
Indiantown	2	100%	1.066	0.000
Long Distance	1006	24%	-	-
N.E. Florida	9	29%	1.872	0.416
Pay Telephone	134	116%	-	-
Quincy	5	67%	0.627	0.000
St. Joseph	14	-46%	0.724	0.259
Southern Bell	1769	11%	0.462	0.180
Southland	1	-50%	0.364	0.364
United	246	-4%	0.285	0.069
Vista-United	2		0.637	0.000
Industry Total	3959	4%	0.432	0.166

IMPACTS OF DEREGULATION AND COMPETITION ON THE PBX/CENTREX MARKET

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I. INTRODUCTION

According to a recent Telephony article, "Centrex II: the Telcos Revenge,"

> When last we saw our hero, Captain Centrex was grasping for every anguished breath.... His old standby analog weapons were quickly brushed aside by PBX-Man....
>
> Luckily for our hero though, PBX-Man's ambition got the best of him. His determination to build a global power base quickly disintegrated into a series of struggles within the PBX gang.
>
> Meanwhile Captain Centrex was quietly building his digital powers.... to challenge PBX Man to a rematch. And this time, the full power of the CO would be brought to bear.[1]

I should add that, Captain Centrex also got Mr. Regulator to grant him increased pricing freedom.

These comic book heros have touched on two of the major points I address below:

> Deregulation has worked. Competition is alive and well; customers have benefited from lower prices and many new features in the PBX/Centrex market.
>
> Competition within "the PBX gang" coupled with enhancements to LEC Centrex service has brought about a resurgence of Centrex.

The third point I address is that past regulatory restrictions may have unnecessarily hindered PBX and LEC efforts to compete; thus, efforts to reimpose excessive regulatory burdens on Centrex should be resisted.

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[1] Carol Wilson, "Centrex II: the Telcos' Revenge." Telephony, p. 28, July 17, 1989.

II. PBX/CENTREX COMPETITION IS ALIVE AND WELL

The telecommunications equipment industry is widely, and correctly, regarded as one of the most competitive in the country. This is particularly true of the PBX market which includes vigorous internal competition as well as competition with LEC Centrex offerings. Indeed, because of this competition, it is appropriate to include PBX and Centrex in a single market -- the business customer switching services market.

Technological, regulatory and market changes dating back to Bell Labs' invention of the transistor have drastically changed this market. AT&T has lost its once dominant position. Major domestic and foreign entrants have captured increasing shares of the market. Prices have fallen dramatically since at least 1981. More recently, slower growth and excess capacity have led to even more intense price competition and to increasingly sophisticated marketing efforts. This has caused some competitors to merge or exit the market; yet, the industry remains extremely competitive. In addition, Centrex has become more competitive as it has begun to catch up with PBX in terms of available features and as the LECs have obtained more regulatory flexibility. The breakup of AT&T was a major factor in the Centrex revival, as it pushed the LECs to focus on Centrex.

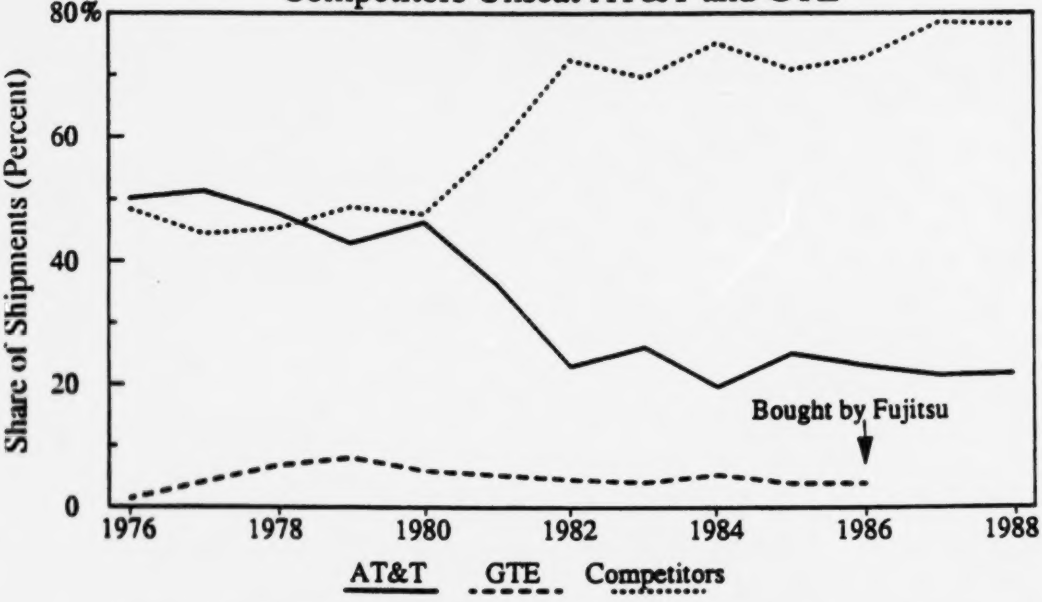
Divestiture also led to complex and ironic relationships in the industry. The BOCs, who were the primary distributors of AT&T customer premises equipment, have emerged as major competitors of their former parent -- both as distributors for competing PBX manufacturers and as suppliers of revitalized versions of Centrex service. AT&T and Northern Telecom are at once the major suppliers for BOC Centrex equipment and their major competitors as PBX vendors. Ironically, competition between these two suppliers has probably contributed to the reinvigoration of Centrex. Further, the largest business customers often use virtually the same switch to serve as a PBX as the BOCs use for digital Centrex.

A. The Changing PBX/Centrex Market

1. What Has Happened to the Market's Structure?

First, AT&T has lost its once dominant position. As shown in Exhibit 1, when measured by percent of lines shipped, AT&T's share declined from roughly 50 percent in 1976 to 46 percent in 1980. From 1980 to 1982 AT&T suffered a precipitous decline in shipments, while the competitors' shipments continued to grow. As a result, AT&T's share declined to only 23 percent of lines shipped by 1982, and since then AT&T's share has been in the 20 to 25 percent range. (GTE also suffered setbacks and bowed out by selling its PBX business to Fujitsu in 1987.)

Exhibit 1
Competitors Unseat AT&T and GTE

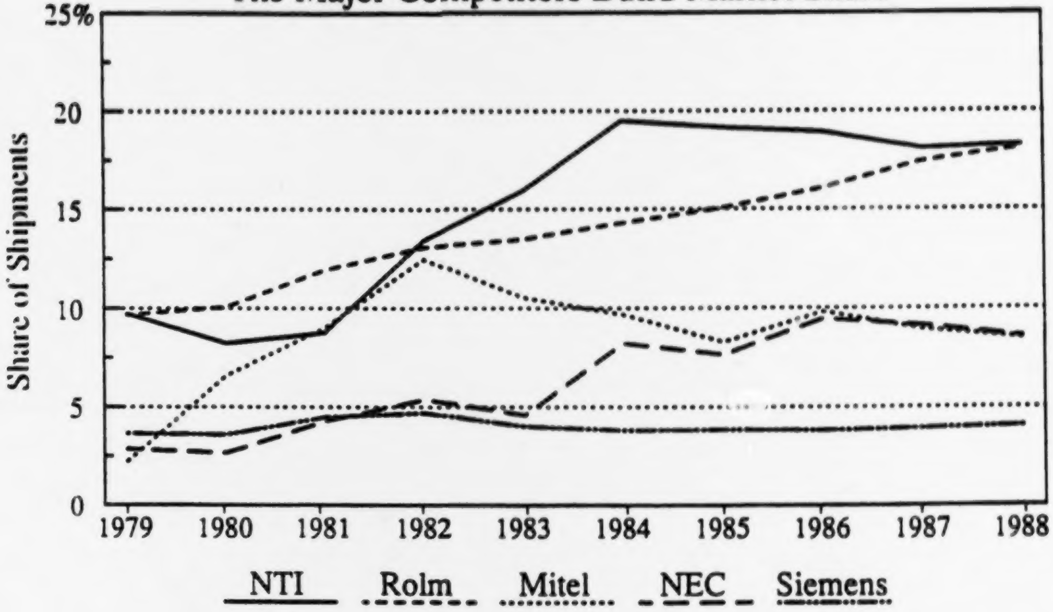


Source: Data from the 1983-1988 editions of NBI's "PBX and Related Markets."

Second, major domestic and foreign competitors have captured increasing shares of the market. From 1976 to 1987, these companies raised their share from about 48 percent to about 78 percent. Four major competitors, Rolm, NTI, Mitel and

NEC, account for the majority of the growth. (Exhibit 2 shows their progress since 1979.) The entry by foreign firms (which actually dates back to the 1970's) brought

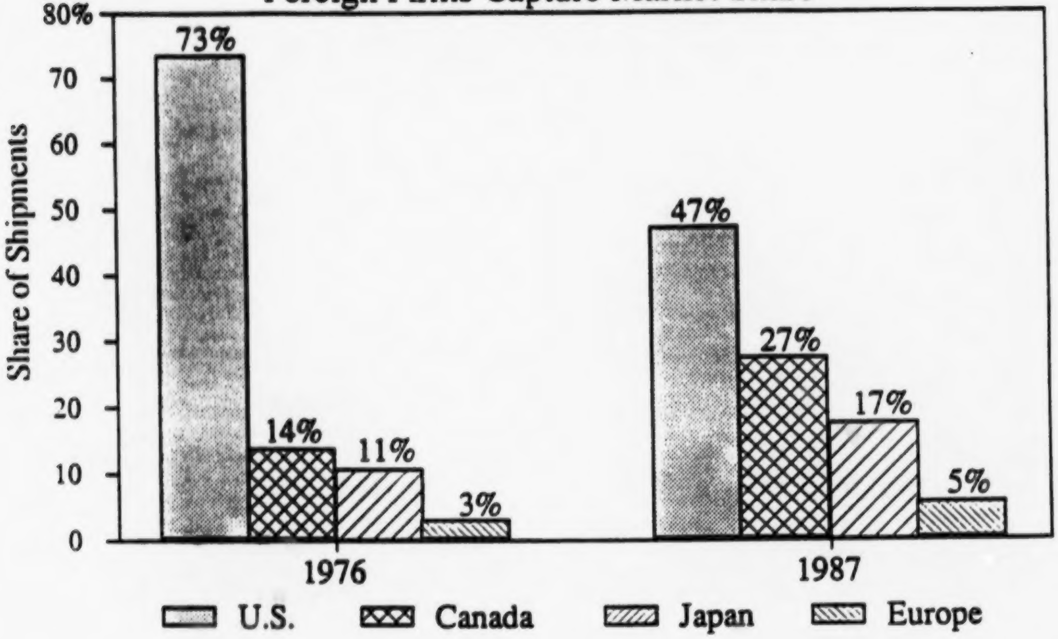
Exhibit 2
The Major Competitors Build Market Share



Source: Data from the 1982-88 editions of NBI's "PBX and Related Markets."

a number of established Japanese, Canadian and European PBX manufacturers into the US market. These companies could draw on their relatively protected home market as a source of funding for research and product development. These competitors, especially Northern Telecom, the Bell Canada equipment manufacturer, acquired a substantial share of the US market. Exhibit 3 shows the dramatic shift from US to international competitors between 1976 and 1987. With Siemens' acquisition of Rolm in 1989, the American share is now down to only about 30 percent and the European share is over 20 percent.

Exhibit 3
Foreign Firms Capture Market Share

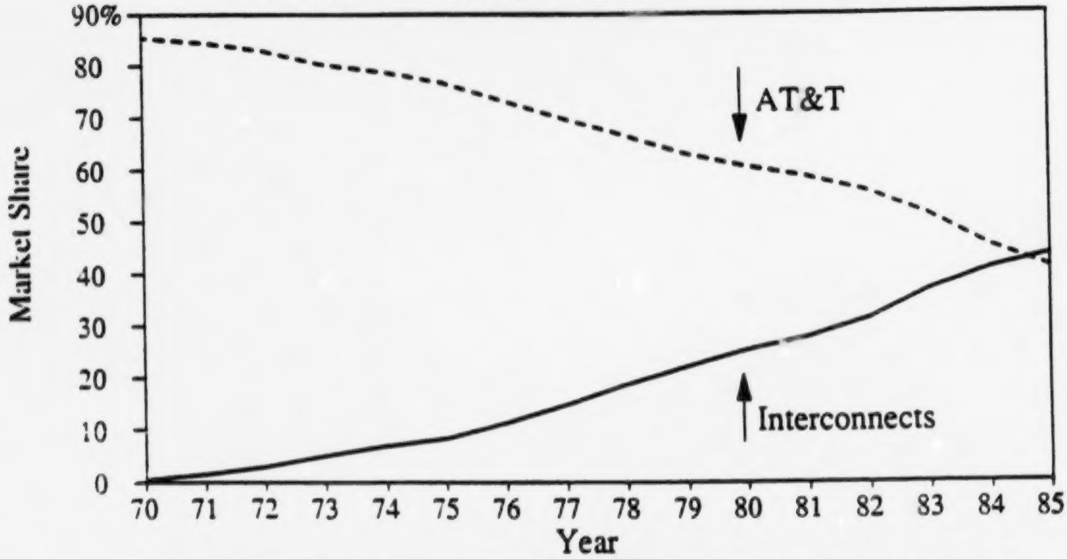


Source: Data are from the 1982-88 editions of NBI's "PBX and Related Markets."

Third, using data on shares of the installed base of PBX lines, which are available from 1970 to 1985, we can see that competitors' inroads began in the early seventies. As shown in Exhibit 4, AT&T's share of the installed base fell from about 85 percent in 1970 to about 70 percent in 1977 and to only 41 percent in 1982. Throughout this period AT&T's base stayed at around 9 to 10 million lines. The interconnects' base went from nothing to 10 million lines. (Interconnects are defined as all companies other than the Bell System or independent telephone companies. Prior to 1984 the "AT&T" share shown in Exhibit 4 includes the Western Electric PBXs sold by the BOCs. In 1984 and 1985 the BOCs no longer distributed AT&T equipment.)

Exhibit 4

The Decline of AT&T's Share of Installed Base



Source: 1970-77 data from 1983 edition of NBI's "PBX and Related Markets."
1978-82 data from 1983 and 1986 NATA Statistical Review.

Fourth, Centrex was able to compete effectively with PBX until 1978 when it began to lose market share; however, it has begun to recover in the last several years. As indicated by Exhibit 5, the Centrex market share grew from 21 percent in 1970 to almost 35 percent by 1978.[2] From 1978 to 1980 the Centrex installed base continued to grow but at only 4 percent per year while the PBX installed base began to grow at about 7 percent per year. This resulted in a change in the trend in market shares, with PBX beginning to gain. From 1980 to 1983 the Centrex installed base actually declined while the PBX installed base continued to grow at about 7 percent. This accelerated the PBX gain in market share. Although Centrex once again began to expand its installed base between 1983 and 1986, its growth was much

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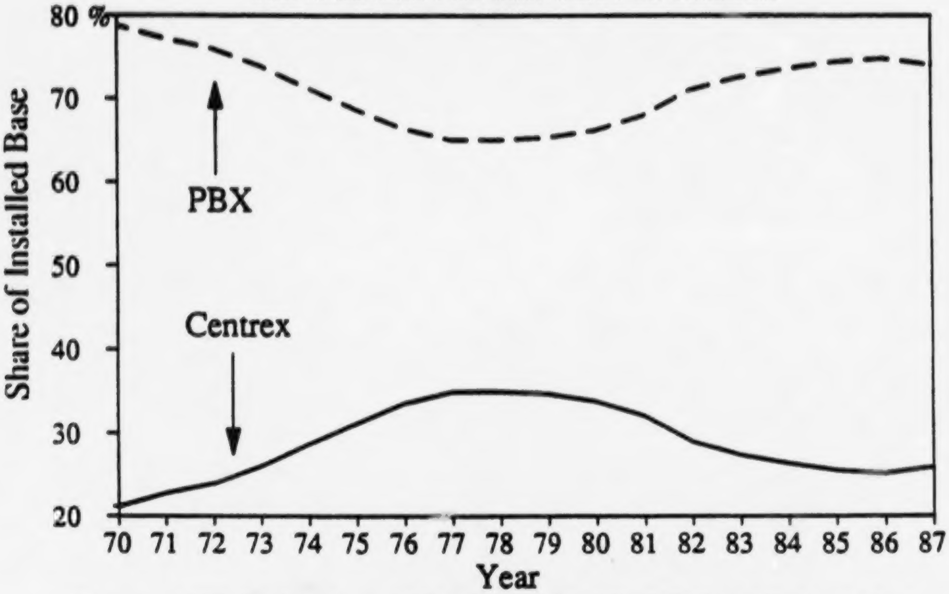
[2] I should note that these data exclude multi-line phone systems known as key telephone systems which have historically been aimed at smaller businesses. For some purposes it would be appropriate to include them in the market share, especially those key systems known as hybrids. These systems have many features like PBXs and usually serve customers with up to about 100 lines.

slower than that of the PBX installed base and Centrex continued to lose market share. Centrex growth from 1986 to 1987 accelerated and, although its installed base was still only about 26 percent of the total in 1987, Centrex appears to have reached a turning point.

Exhibit 5
The Rise and Fall and Rise? of Centrex



Source: 1970-77 data from 1983 edition of NBI's "PBX and Related Markets."
1978-82 data from 1983 and 1986 NATA Statistical Review.

2. What Has Happened to Conduct and Performance?

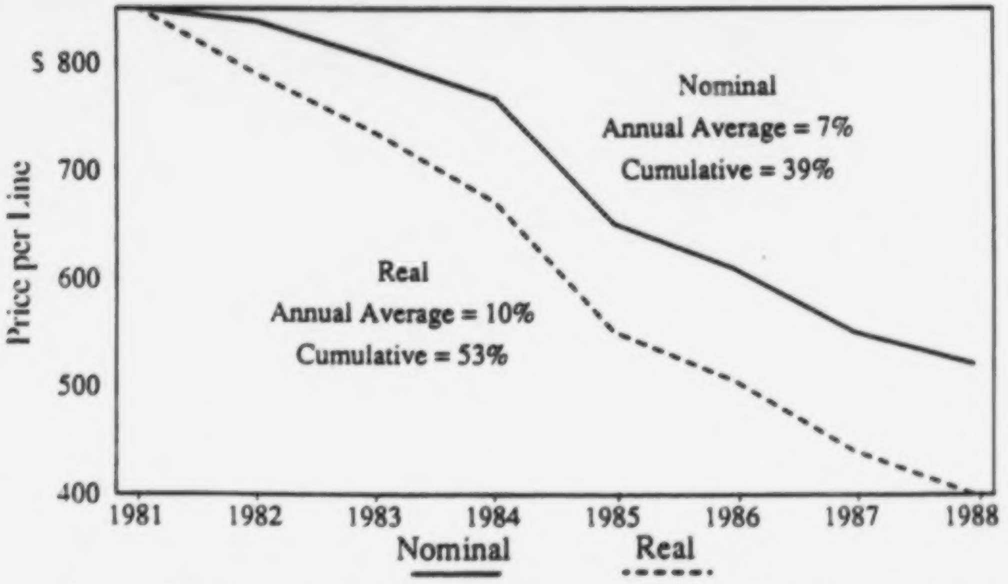
a. Competition Among PBX Manufacturers

Prior to 1980 competitive entry and expansion occurred and much of the competition centered on efforts to meet growing demand and to differentiate PBXs on the basis of technology and features. In addition, since the market was expanding rapidly, price competition was less intense than in subsequent years. Competition began to heat up with the entrance of firms like Mitel which sought to gain market share by competing largely on the basis of price. Indeed, Mitel managed to capture 12.5 percent of the market by 1982, after only four years of selling in the US and its share has since hovered at around 9 percent.

Exhibit 6 shows the decline of prices in both nominal and constant 1981 dollars. In nominal terms prices have fallen by about 6.8 percent per year since 1981, and adjusted for inflation they declined by about 10.2 percent per year. As a result real prices are now less than half of their 1981 level. Since divestiture two factors have intensified price competition.

Exhibit 6

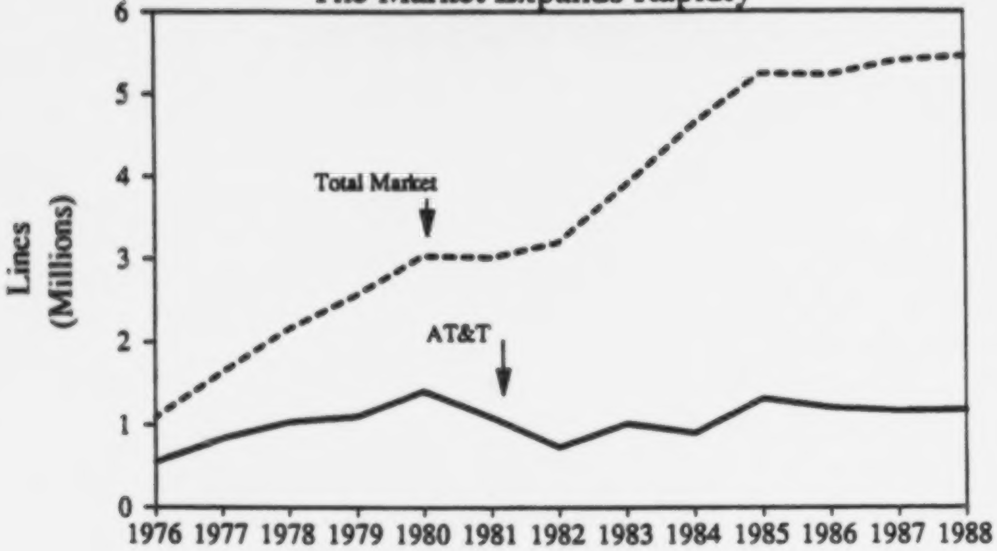
Real PBX Prices Have Declined by 53 Percent Since 1981



Source: Data from the 1987 and 1988 editions of NBI's "PBX and Related Markets."

- Leveling off of demand growth (see Exhibit 7) for digital PBXs as many major customers completed their transition to the newer digital PBX technology; and
- Excess capacity in the PBX market -- Dataquest reported that the five major manufacturers had enough capacity to serve the entire market. [Dataquest Research Newsletter, "The 1987 PBX Market: A Year of Turmoil, Market Share Shifts, and Unmet Expectations."]

Exhibit 7
AT&T Shipments Level Off As
The Market Expands Rapidly



Source: Data are from the 1983-88 editions of NBI's "PBX and Related Markets."

Profit margins have been declining since at least 1984. Comprehensive data on profit margins for the manufacturers are not publicly available; however, losses have been reported for both Rolm and Mitel and trade press accounts are replete with references to "fierce rivalry," "cut throat competition," price wars and declining margins.[3] During 1987 and 1988 Rolm, which was then an IBM subsidiary, lost more than $100 million per year. Mitel's annual reports show losses from 1984 to at least 1987.[4]

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[3] See, for example, the Wall Street Journal article "Rivalry Is Fierce in Growing Market for Telephone Switching Systems," (February 10, 1984).

[4] John Markoff, "IBM To Sell Rolm to Siemens," New York Times, p. D.1, Dec. 14, 1988.

As a result of the intense competition, some manufacturers and many distributors have left the market or been acquired. According to NBI's annual PBX Market reports, the number of PBX manufacturers in the US market declined from 30 in 1986 to 22 in 1988.[5]

Another result of the competition has been to focus increasing efforts on distribution and marketing in order to differentiate one's product and gain market share. To do so Siemens acquired IBM's Rolm PBX subsidiary. (IBM, perhaps embarrassed over pulling back from another telecommunications market, refused to call the deal a sale. It called it a "transfer of assets.")

Many firms have exited or been acquired in the interconnect distribution sector also. The Wall Street Journal article noted above reported that the "cut throat competition" resulted in losses to a major PBX distributor, Communications Corporation of America. It also revealed that Northern Telecom's acquisition of two of its distributors was "partly because they were ailing from pricing pressure." More recent trade press articles and reports contain similar information:

- According to a Telephony article from 1988, interconnects continued to face problems due to "oversupply from manufacturers and overlap in distribution channels." The president of Tel Plus is quoted as saying that "with margins eroding due to extreme price competitiveness, it is becoming increasingly clear that the PBX vendors who will survive are those that are stable, established, and financially very sound."[6]

- NBI also reports that the entrance of the RHCs siphoned off seven percent of the business in the small PBX market which "came at the expense of small interconnects, independent telcos, and supply houses." Many of these interconnects, which were "unable to engage in protracted

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[5] NBI, "PBX and Related Markets," 1987 and 1988 editions, Exhibits 2-7 and 3-7, respectively.

[6] See Telephony, p. 35, April 11, 1988. Communications Week of July 14, 1986 described the interconnect market as one where "mere survival is half the battle." The demise of the small interconnects continued and "many of the smaller distributors of customer premises telecommunications equipment have either fallen victim to competition from the Bell companies and equipment manufacturers or have been gobbled up by larger interconnects." Of the top 15 interconnects in terms of revenue, three actually lost money in 1985, and others, such as the largest interconnect, Tel Plus, found their sales falling considerably short of projections.

> price wars and unable to find buyers have shut down."[7] In 1984 the RHCs entered the market as distributors and captured 8.5 percent of the PBX lines shipped. From 1985 on they have had about 13 to 14 percent. Their entry provided additional national distribution channels for AT&T's competitors and may have contributed to the increased price competition following divestiture. The Huber report shows that almost all of the RBOCs established equipment sales operations in their former siblings service territories.[8]

Despite these reports, the shakeout may be coming to an end. The North American Telephone Association (NATA) predicts in its 1989 Interconnect Industry Review (page 5) that the shakeout of marginal interconnects will continue for the near term. However, they also say that this trend will reduce the intense price competition that has existed since 1984. NATA also reports an increase in revenues for the overall interconnect industry but this seems to be largely from the sale of peripheral equipment. This category shows growth of approximately 32 percent compared to a four percent increase in interconnect revenues from new systems.[9]

Finally, while there are fewer firms manufacturing PBXs, the industry remains extremely competitive. There are now three major multinational PBX firms, AT&T, Northern Telecom and Siemens/Rolm, which each have about 20 percent of PBX shipments. There are two other major suppliers with about nine percent each. Further, the remaining major firms are diversified equipment producers who have also increased their distribution and marketing efforts. In addition, there is still a substantial fringe of established smaller suppliers, many of whom serve specific niche markets.

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[7] Northern Business Information, "Small Business Systems Market," 1985, P. 50.

[8] See p. 16.7; the report says that: "virtually every RHC's CPE operation is presently competing against AT&T's and virtually every other RHC's in virtually every region."

[9] North American Telephone Association, "1989 Interconnect Industry Review," Table 1.

B. Centrex/PBX Competition

In Section III below, I discuss how Centrex declined between 1978 and 1986. In this section, I focus on LEC efforts to stem the decline.

Divestiture stimulated the BOCs to revive Centrex and compete more aggressively because they were not permitted to manufacture their own PBXs. The LEC's response to the increasing competition in the PBX/Centrex market in the post divestiture period has been threefold. First, they have sought to increase the Centrex features available on the switches by pressuring the major manufacturers, Northern Telecom and AT&T, to make software and hardware enhancements for Centrex. This effort appears to have been reasonably successful because of increased competition in the central office switching markets after divestiture. In particular, Northern Telecom has become a major PBX central office switching provider and along with other less successful entrants has put pressure on AT&T to compete more aggressively in the central office switching market than it might otherwise have done. Thus, although AT&T may have had some motivation following divestiture to limit the development of Centrex features in order to stimulate its business in the PBX market, competition deterred it from doing so. The competition in the PBX market meant that any benefits from expanding that market would not necessarily accrue to AT&T while the competition in the central office market itself meant that AT&T would have to be responsive to the demands from its central office customers or face the prospect of losing them and a much larger volume of business than it has in the PBX market.[10]

Second, the BOCs have increased and rationalized their own marketing efforts which were in disarray following divestiture.

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[10] Hausman and Kohlberg report that "Digital Centrex on the AT&T 5-ESS was two years behind schedule." However, "development may have been more difficult than anticipated . . . and equal access many have used scarce software development resources." They also say "the argument is made that AT&T has no incentive to endanger its $4 billion central office switch operation in favor of its $700 million PBX operation, especially given the very competitive situation in PBXs that has led to low, if any, return on investment." Jerry A. Hausman and Elon Kohlberg, "The Future Evolution of The Central Office Switch Industry," Future Competition in Telecommunications, edited by Stephen P. Bradley and Jerry A. Hausman, 1989, p. 208.

Third, the LECs have secured pricing changes and pricing flexibility from regulators. A number of state regulatory decisions have made it possible for Centrex to compete on a more equal footing. These decisions granted pricing flexibility to the LECs for Centrex service and permitted the LECs to offer rate stabilization plans insulating customers from tariff increases and contract pricing on custom installations for the major customers. These pricing options gave customers the stability for switching service costs that only PBXs offered in the past. Although prices have probably been reduced in many market segments in the Centrex area, comprehensive data are not readily available. A recent Communications Week article comparing PBX and Centrex service reported that Centrex was still somewhat more expensive than PBX for a typical installation.[11] NATA, the interconnect industry trade association, released data which suggests that the reverse is true in at least some regions.[12]

More recently the turmoil in the interconnect market may have caused customers to look more favorably at Centrex. In this environment the traditional ability of LECs to relieve customers of maintenance problems, to handle upgrades on a line-by-line basis and to provide a stable, well financed source of service has also helped to stimulate demand. (The ability to provide a stable source of service has also probably benefited the larger PBX companies like AT&T and NTI.) In addition, the LECs can protect their customers from investing in technology and software that may be obsolete very quickly. The loss of the investment tax credit has also worked in favor of Centrex.

III. REGULATION HAS HINDERED COMPETITION

The changes that have affected Captain Centrex and PBX Man are attributable to a combination of regulatory, technological and market forces. Often regulation has interfered with competition.

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[11] Saroja Girishankar, "Running A Close Race," Communications Week, September 4, 1989, pp. 31, 34.

[12] North American Telecommunications Association, "Centrex Survey," 1988.

Until the 1968 FCC Carterphone decision allowed customers to purchase and attach CPE to the network as long as it was not technically harmful, PBX manufacturers could only distribute their products through the telephone companies. Most of the PBX equipment in place up to then was produced by the vertically integrated subsidiaries of the telephone companies. Thus, the Carterphone decision was the major catalyst to competition.

After regulatory restrictions were reduced, technological change had a pronounced effect. The convergence of telecommunications and computer technology and developments in semiconductor technology made it possible for entrants to offer modern electronic alternatives to the Bell System's PBX and Centrex options. These devices also reduced the physical space and thus the opportunity cost of floor space needed to accommodate user owned switches. The Huber Report points out the irony of Bell Labs having started the semiconductor revolution that has sparked and nurtured the interconnect industry. In addition, the trend towards use of computer technology in the telecommunications market increased the pool of potential entrants in the switching and PBX markets.[13] Indeed, two of the PBX market's faster growing competitors, Rolm and Mitel, emerged from the computer and semiconductor markets, respectively. The increased use of digital technology in the late 1970s and early 1980s provided an additional boost to AT&T's competitors because AT&T was somewhat slow in developing a pure digital PBX. Perhaps due to the availability of new capabilities and the stimulus of competition, the market as a whole expanded dramatically. Total lines shipped tripled between 1976 and 1982 permitting easier entry for new firms and expansion by existing competitors (see Exhibit 7). Market expansion generally means that firms can gain market share without cutting into the sales of the incumbent. Further, with substantial growth in the overall market, the incumbent may not be able to meet the new demand from his existing capacity. Thus, entrants will find it easier to compete on an equal footing.

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[13] According to Noll and Owen, "electronic switching technology . . . caused the convergence of telecommunications and computer/electronic equipment manufacturing, bringing potential competitors to the telephone equipment business." Roger G. Noll and Bruce M. Owen, "United States v. AT&T: An Interim Assessment," in Bradley and Hausman, op. cit., p. 144.

The regulatory structure confronting AT&T until the early 1980s hindered the rapid introduction of new PBXs by the Bell System. In particular, until the FCC's Computer Inquiry II decision in 1980, AT&T was confined to offering PBXs as tariffed (leased) options and thus, unlike its unregulated competitors, needed to file and update tariffs to offer new services and change existing ones.[14] Further, the CI II decision required that enhanced services and CPE be offered on a deregulated competitive basis only by a fully separate subsidiary; and, that subsidiary, American Bell International, was not started until 1983. By that time AT&T's share of PBX shipments had slipped to only about 20-25 percent of the total. (See Exhibit 1.)

Similarly, at that time, as AT&T and the BOCs hammered out the details of the divestiture, the BOCs decided to sell CPE and sought approval to do so without a separate subsidiary; 10 days after divestiture, the FCC ruled that the BOCs would also be required to use separate subsidiaries to sell unregulated equipment and services. Later that year, the BOCs were given permission for their unregulated subsidiaries to act as sales agents for both CPE and network services on an integrated basis as long they allowed independent sales agents to operate on the same terms and conditions as the affiliates. These rapid changes were of course a source of confusion and frustration to the former Bell System customers who were accustomed to dealing with a single point of contact at the BOCs for all of their telecommunications needs. This caused at least part of the decline of AT&T's market share in the early 1980's.

When the FCC's 1986 decision allowed AT&T to once again unify its marketing forces, the company was able to develop a more effective and efficient sales force. This has undoubtedly helped it to avoid further losses of market share.

What Accounted for the Decline of Centrex?

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[14] Northern Business Information, "PBX Market," 1983, pp. 8-11.

One is tempted to respond: the rise of PBX. However, the answer appears to be that Centrex declined because of regulatory restrictions and technological and strategic marketing factors. We have already considered the key regulatory decisions which directly stimulated the PBX market and thus indirectly slowed development of the Centrex market.

Other regulatory or government factors affected Centrex directly by inhibiting the ability of the Centrex providers to compete in the business customer switching services market. These factors included traditional regulation which hindered the ability of Centrex providers to match pricing changes by the highly competitive PBX firms. This probably contributed to AT&T's increased focus on the PBX market. Indeed, the alleged AT&T "migration strategy" of seeking to introduce new PBXs with more advanced semiconductor technology as a means of retaining PBX and Centrex customers may have contributed to the slowdown in Centrex growth beginning in 1978. Note that AT&T was not in fact able to hold onto its share of the installed base of PBX lines for reasons described above. As shown in Exhibit 3, AT&T's installed base in the PBX market steadily eroded from 1970 to at least 1985.

The Computer Inquiry II restrictions on enhanced service and the MFJ proscription of information services, prevented the introduction of important features like voice mail and least-cost routing which have been available for some time on PBX systems.

In addition, it is likely that the turmoil created by the process of implementing the divestiture agreement contributed to the decline of Centrex in much the same way as it did for AT&T's PBX share. Jerry Stern of the Eastern Management Group put it more bluntly. According to him, "between 1984 and 1986 the RHCs were in such confusion that service was sometimes difficult to obtain." (Telephony "Centrex II: The Telcos Revenge," July 17, 1989, p. 29.)

IV. REGULATORY IMPLICATIONS

What are the implications of the regulatory and competitive history for current policy?

Deregulation has resulted in numerous new options and lower prices for users. Each of the options available for obtaining switching service has its own strengths and weaknesses. Both the PBX providers and the LECs are trying to satisfy demands for improved network management and customer service. In the past regulation stifled potential competition to the LECs' PBX and Centrex services. Regulation also limited LEC pricing options; and, more recently, regulatory and MFJ restrictions have served to artificially inhibit Centrex from providing features which are highly valued by customers. Requests for future regulatory handicapping which will benefit the PBX companies should be carefully examined. In view of the vigorous competition in the business customer switching services market, minimal regulation is called for.

Nevertheless, some have expressed concern about possible anticompetitive practices against the PBX suppliers by the LECs to promote Centrex. The dependence of PBX users on the LECs for access to the network coupled with access prices that are typically lower for Centrex than for PBX lines has led to charges of predatory pricing through monopoly bundling (of Centrex access and switching services), applying a price squeeze by charging high PBX access charges versus low charges for Centrex loops and cross subsidization of Centrex by monopoly services. Evaluating such allegations requires consideration of the facts in particular cases. However, in evaluating such claims, a number of factors should be kept in mind.

First, the falling prices and losses experienced in the PBX sector reflect intense competition and turmoil within that sector itself.

Second, the despite the turmoil, the competitive structure of the industry will serve to limit potential abuses. There are now 5 major multinational competitors, established distributors and a large fringe of smaller competitors in manufacturing as well as hundreds of interconnects (who now include the RBOCs which are competing in territories outside their own). The key factors regarding PBX/Centrex competition are that PBX manufacturing and distribution have consolidated in the last few years and the major vendors are multinational companies. Thus, although the LEC Centrex offerings have larger market shares than individual PBX vendors in some areas, several of the major PBX firms have nearly equal shares in each geographic market; and perhaps more important, on a national or international basis, the major PBX firms have much larger shares than any LEC. Thus, efforts by an LEC to raise its own future profits by driving out PBX firms would be fruitless. It would have little if any chance of driving out the major firms because these firms can use earnings in other geographic markets to offset losses in any one area. Further, if they were forced to exit a given market they could simply reenter if the LEC sought to raise prices. Product diversification (like geographic diversification) also would make it possible for the major PBX manufacturers to reenter the PBX market if they were somehow forced to retire from it. They would be able to readily reenter if the LEC tried to raise prices because they also manufacture the switches used for Centrex service. In addition, the continued existence of numerous small PBX manufacturers and suppliers also suggests that entry barriers remain low.

Third, the two largest competitors, AT&T and Northern Telecom, have substantial insight about the cost of Centrex because they are the major providers of central office equipment. Thus, they would be able to recognize below cost pricing for switching services. They are also major suppliers of outside plant and thus should be able to evaluate the costs and pricing of access lines. I should point out, however, that their incentives to press the issue are mixed. On the one hand they could benefit somewhat from the reintroduction of the regulatory umbrella. On the other hand the LEC central office market is a richer source of revenues for them. (See footnote 10, above.)

Finally, divestiture created seven new competitors which regulators can use as additional benchmarks in determining whether there are abuses in a particular jurisdiction. This does not mean that one can simply make direct comparisons of the rates charged in various areas for a given service. It is necessary to control (statistically) for differences that may affect costs. Such factors as the mixes of switching and outside plant technology and capacity utilization can significantly affect costs and thus appropriate prices. Nevertheless, if (controlling for such differences) rates are substantially different in one area than others, it may be appropriate to conduct a more detailed analysis.

In the event that it is necessary to conduct an analysis of Centrex pricing, policy makers should employ the approach set forth by my colleague, William Taylor, in his paper on the basic principles for efficiently regulating competitive intraLATA services, including Centrex:

> Permit pricing flexibility across services subject to: (1) the overall rate of return constraint and (2) the requirement that service prices exceed incremental cost where the costs of noncompetitive essential services of the LEC (e.g., access) are taken to be the tariffed rate that competitors are charged for the service.

He also notes that the concern with cross subsidy which motivates these rules would be greatly reduced with price cap regulation, because it would reduce an LEC's *ability* to raise rates for the noncompetitive service and its *incentive* to cross subsidize in order to increase its rate base.[15]

As Dr. Taylor explains, the above approach will both prevent cross subsidy and promote economic efficiency.

> It is generally true that a service is not being cross-subsidized... if its price exceeds its *service* incremental cost...., [since] the customers of the service ... pay enough to compensate for the costs they cause. ... If [the incremental cost] test is passed -- and the overall rate of return constraint is not violated -- the LEC's price will be efficient in the sense of not encouraging entry of firms with higher costs and not preventing the entry of lower cost competitors.[16]

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[15] William E. Taylor, "Regulating Competition for IntraLATA Services," *Telecommunications in a Competitive Environment, Proceedings of the Third Biennial Telecommunications Conference*, National Economic Research Associates, April 12 - 15, 1989, p. 36. As he also notes, even under price cap regulation, these principles may be useful for antitrust reasons.

[16] Taylor, p. 42.

Furthermore, since there is competition within the business customer switching market, an LEC could not profitably engage in cross-subsidization within that market, e.g., by charging excessive prices to smaller Centrex customers in order to subsidize the prices charged to larger Centrex customers. If prices for some customers were too high, they would be able to switch to PBXs or key sets. Note also that since PBX vendors have no restrictions on their pricing structure across market segments and as suggested by the above passage, Centrex pricing flexibility is needed to ensure economic efficiency.[17]

The competition within the business customer switching market is thus sufficiently developed that many regulatory bodies have granted substantial flexibility for Centrex pricing. That flexibility should be maintained with as little regulatory interference as possible.

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[17] See Taylor, pp. 47-48 for a further discussion of this point.

The Quasi-Public Network:
Issues of Pricing and Access

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by

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Abstract

State and regional networks originally designed as research networks are, in some respects, better described as quasi-public networks. These networks are part of the Internet and provide access to a vast and growing body of users and aggregation of computing and data resources. Communications costs in the Internet are keyed to availability rather than actual use, with the cost of availability usually bundled into institutional overhead. This gives the Internet extraordinary potential as a publishing environment. Although uncertainty about acceptable cost recovery practices inhibits the publishing of proprietary information, the phasing out of the federal subsidy and inter-network competition will induce the regional networks to permit commercial publishing. This may be achieved in part by spinning off for-profit subsidiaries which share use of facilities with their non-profit parents and provide vehicles for capitalizing the further development of broadband services.

Background: The Evolution of the Regional Research Network

Spurred by seed funding from the National Science Foundation (NSF) and the national connectivity provided by the NSFNET backbone network, a number of regional and state computer networks have been formed in the course of the past five years to support communications and resource-sharing within the scientific research community. These networks share common protocols based on the TCP/IP protocol suite and are therefore interoperating: a user on one can access a computer on another network without being aware that a network boundaries are being crossed. Together with certain special purpose networks, federal agency networks, and the NSFNET backbone, these regional networks comprise the national Internet.

The Internet is not simply a communications system but an extremely complex environment for computing, communicating, publishing, and information retrieval. The original impetus for the NSF funding was access to remote computing resources, and computing needs remain the primary rationale for high-bandwidth interconnection. But there is an ineluctable dynamic between computers, networks, and data, just as there is between the processing, communication, and storage of information.

It is difficult to find a metaphor for conveying the full functionality of the Internet environment. In some respects, Compuserve provides similar functions: access to a remote computer; communications among users; bulletin board features; and remote file retrieval. However, while Compuserve is centrally operated and maintained, the Internet is an aggregate of independent operations. The Internet provides access to 50,000 computers and more than 500 local or wide area networks. It has no subscribers per se, but it has over half a million users (twice the number of Compuserve subscribers) -- around a million when BITNET access through mail gateways is considered. Another half million have mail access through gateways from commercial services such as Compuserve and MCI-MAIL.

Both the Internet and Compuserve are standardized user environments; Compuserve, however, is refined, integrated, and user friendly -- as one would expect from a commercial product. The Internet environment is complex, non-proprietary, and adaptable to specialized uses. Its functionality is not well-integrated, and it is often confusing to new users.

Since it ordinarily appears seamless to the user, the Internet is often loosely referred to by its users as "the network." In fact, the regional networks are autonomous and may differ in constituency and structure. Classed as "mid-level networks," regional and state networks occupy an intermediate position in a conceptual hierarchy that extends from the NSFNET backbone at the top to local area networks at universities and other research centers at the bottom.

In some cases, there are state networks between the regional networks and individual schools, either directly as members of the regional or indirectly through state universities which are members of the regional. (See Figure 1.) However, some state networks function as regional networks: For example, NYSERNET is a state network which is the sole mid-level network between the NSFNET backbone and NYSERNET's member institutions in New York; BARRNET, CERFNET, and LOS NETTOS are all mid-level networks located entirely within the State of California. Some universities and corporations are members of more than one regional network. Regional networks, even some state networks, are not necessarily limited may occasionally serve institutions or companies in other states.

Some networks have been funded by NSF specifically to provide access to consortium-operated supercomputer facilities, such as the John Von Neumann Center in Princeton. These networks, which overlap the regional networks, are "special purpose" or "resource-sharing" networks. Although membership in

NSFNET Backbone

Regional Network

[subregional state network]

Institution / LAN

(LAN Node / Machine)

(Individual Account)

Figure 1. The Internet "Hierarchy"

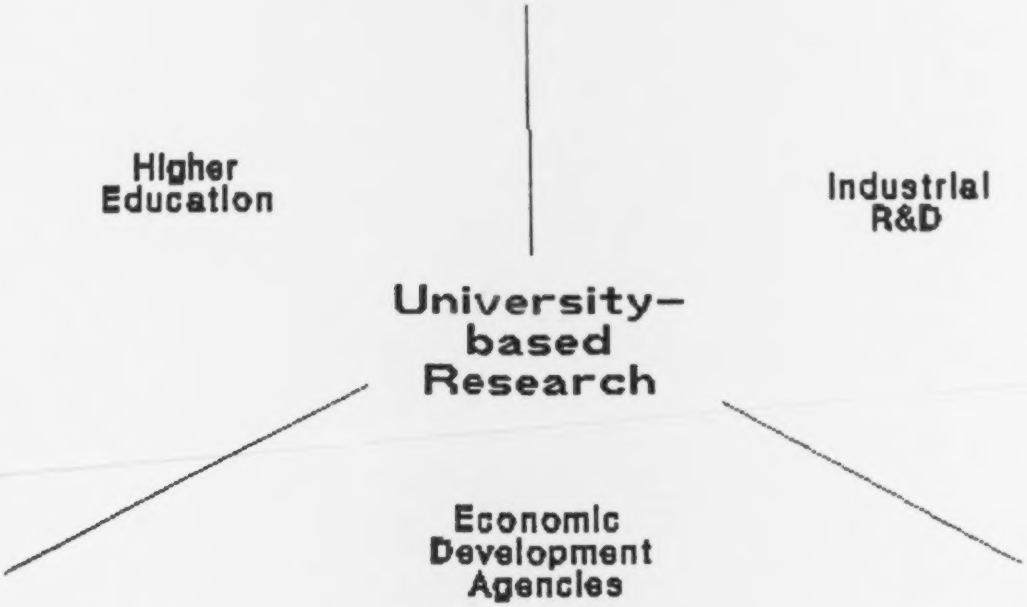
Higher Education
Industrial R&D
University-based Research
Economic Development Agencies

Figure 2. Core Constituency of the Regional Network

the consortia roughly represent geographic regions, there are many exceptions. Despite the original purpose, traffic on these networks is not limited to supercomputer access.

While NSF's investment objective has been to support science research, principally federally funded research, funder interests become much more diffuse at the lower levels of the hierarchy. Universities, which invest heavily in LANs and local computer facilities, see the networks as providing connectivity with the wider community of scholars and researchers whatever their discipline -- the model provided by BITNET, a widely used general purpose academic network. At the state level, where the politics of funding may require aggregating a diverse community of potential users, the networks are typically portrayed as vehicles for economic development, specifically for encouraging communication and collaboration between higher education and industry. However, state networks may also be designed to serve other public institutions -- libraries, schools, and even the routine needs of certain state agencies.

What is a Research Network?

There is an inherent tension between two different senses of "research" as applied to the regional networks and the NSFNET -- as there was in the original ARPANET. In one sense, these networks serve researchers by facilitating resource-sharing and interaction among funding agencies and researchers, whether in government, industry, or academia. In the other sense, the research networks are experimental rather than operational (or "production") networks. It is not always practical to distinguish the two since experimental services move through different phases, becoming more and more reliable and serving a increasingly wide set of users. Thus, the ARPANET proved the viability of packet-switching technologies and paved the way for commercial packet-switched networks, such as Telenet and Tymnet, as well as for the current internet.

The current NSFNET backbone is T-1 capacity, 1.5 Mbps, hardly experimental. But the plan is to move to T-3 (45 Mbps) and then to 1-3 Gigabits per second, perhaps by 1994-96, which will indeed push the technology. An experimental "National Network Testbed" (NNT) is already planned to provide advance testing and experimentation in a high-bandwidth environment. Both the operational Internet and the experimental NNT are overseen by the FRICC (Federal Research Internet Coordinating Committee), which includes NSF, DOD, DOE, NASA, and HHS -- although the different agencies have different interests in the experimental and operational aspects of the network.

The Research Network as a Quasi-Public Network

The experimental side of the Internet exists primarily at the national level. In general, the mid-level networks are operational rather than experimental; they are research networks by virtue of the community they connect. Even so, there are significant differences among them in terms of constituency. Some, such as BARRNET, have a strong complement of corporate members. SURANET, on the other hand, is substantially limited to higher education, government, and nonprofit institutions.

Political coalitions have formed to accommodate traditional policies favoring educational institutions and local interest in regional economic development. Some regional networks explicitly include both education and research -- as does the National Research and Education Network (NREN) espoused by EDUCOM, Senator Gore, and the recent report of the White House Office of Science and Technology Policy.[1] However, it is unclear how far the network constituency is to extend into areas of education, government, and industry away from university-based research. (See Figure 2.) As it is, the draft NSFNET guidelines (see appendix) are noncommittal toward many areas of possible use, and most regional networks do not have written policies on acceptable use.[2]

Similarly, political interests at the state and local may expand the education constituency to include community colleges, state and local libraries, even high schools. While little has been done to date to connect these organizations, state funding has often been premised on the expectation that the network would be open to them. Smaller states, in particular, are likely to look closely at the economies that may be realized by serving the operational needs of a variety of state agencies with the same data network. Serving educational and other state needs at the county level and below requires a network of finer granularity and a much larger investment -- but the incentives to eliminate separate leased lines and aggregate users may well prevail.[3]

At the same time, there are advocates for extending industry use of subsidized networks through the R&D process through the product development phase.[4] This is seen as an investment in national competitiveness along the lines of antitrust exemptions for cooperative research and subsidized industrial research consortia such as Sematech.

This gradual expansion of constituency need not proceed only at official state and regional levels; it can also proceed through individual institutions connected to the networks. Universities setting up neighboring research parks may elect to provide companies with network services through the university's local area network LAN, or even simply through an account on a university computer. The company may thereby have a "backdoor" connection to the regional network and the Internet, which may be invisible to the regional network. Some regional networks have a broad policy against such connections; others simply want to be informed of what connections exist.[5] Again, this is unchartered ground: There is considerable difference between a large company generating enough traffic to warrant direct connection to a regional network and a consultant with an account on a particular research program's minicomputer.

The hierarchical model of discrete exclusive jurisdictions fails under scrutiny. The regional networks are a compromise between the objective of encouraging local investment and autonomy within a political framework and the desire to encourage market competition and avoid federal regulation, and they operate in a complex, shifting environment with few rules and little precedent in which policies of inclusiveness and exclusiveness quietly clash.

On the one hand, the users of these networks are a privileged community benefiting from federal and state subsidies targeted to research, education, and similar public interest purposes. The remaining local costs are generally bundled into institutional overhead, so that individual users usually incur no usage sensitive charges -- as they would normally incur for toll telephone calls. Thus, the public subsidy, the limited network resources, and the lack of accountability for individual use argue for restricting the growth of the user community and establishing controls on access and users.

Arrayed on the other side are arguments for a broader, more inclusive environment. As discussed above, negotiating the subsidy may require broadening the beneficiary base, real or potential, as a political matter. If the network is seen as important educational resource, equity concerns may dictate making it available to community colleges as well as four-year colleges and universities. There are clear economies of scale where users can be aggregated -- i.e., especially for traffic within and between urban centers, and, as will be discussed below, the nature of data communications is such that different uses and users can be accommodated efficiently without a commensurate increase in network resources. The development of both basic and specialized network services often depends on achieving a critical mass of users. Given the planned phase-out of federal support for the regional networks, network connections and membership fees will be an increasingly important source of support. If the networks cannot accommodate direct connections, these will be made indirectly (through subregional state networks or other network members) with less benefit to the network. Or, other more competitive regional networks will move in to offer the connection.

As the regional networks grow -- and many are growing at rates in excess of 20% per month -- the market for network services will grow, forcing the question of whether commercial services that cater to research and education communities will be permitted to provide services on the networks. In general, the more successful the networks are, the more questions will be posed concerning whether they are competing with commercial networks such as Telenet, Compuserve, and Easylink -- and whether such competition is fair given the regional networks' government subsidies and tax-exempt status. Ultimately, the regional networks can only insulate themselves from such charges by restricting access and use by commercial services -- i.e., by limiting the usefulness of the network -- or by relinquishing their subsidies and special status.

If they prove valuable to their users and successful in expanding their user base, the networks must also face further questions of identity. If they are not available to small businesses and individuals on equitable terms, they will generate political counter-pressures and antitrust scrutiny. On the other hand, they will not want to be regulated as common carriers by the FCC and state regulatory agencies.[6]

The expansive, indeterminate constituency of the regional networks suggests that they may be seen as "quasi-public" -- publicly obligated but not public available. The regional networks are not public networks in the common sense of the term, as are Telenet, Compuserve, Easylink, and other commercial network services which are offered to the general public. However, the regional networks are conceived and operated in the public interest -- to support research, education, and related uses which generate externalities that benefit the public. They will generally be operated by public institutions or agencies or as tax-exempt "public charities" under Section 501(c)(3) of the Internal Revenue Code. Unlike BITNET, a private academic network that enjoys no direct public subsidies, the regional networks typically benefit or have benefited from public funding at the state or federal level or both.

NSF Support for Regional Networks

The NSF subsidizes the Internet at three levels:

- -- ongoing operating support for the NSFNET, the backbone network;

- -- the development of regional networks (in two or three stages); and

- -- university connections to regional networks (one-time grants, but often including leased line costs for the first two years)

In short, NSF has made a long-term to commitment to fully supporting connectivity at the national level while it is helping universities only with initial costs of Internet connection and provided they are willing to invest heavily in local networking, technical support, user support, and a commitment to Internet connection over the long term. NSF's support for the regional networks falls in between in terms of both proportion of support and period of support.

NSF has provided seed funding for most of the regional networks with the expectation that they would eventually become self-supporting. While NSF asserts a continuing interest in the traffic traversing the NSFNET backbone, the agency is not appear concerned about uses that may be made of the mid-level networks it has seed-funded. The mid-level networks are thus free to set their own internal policies on connection, access, and use -- as well as policies for direct connections with other networks.[7]

The regional networks are in a central, entrepreneurial, and very vulnerable position in the Internet hierarchy. Unlike the universities, they exist only by virtue of NSF's choice of a tiered network design, and although they are the product of NSF policy and funding, they are accountable to a diverse membership of institutions. The deficiencies of the hierarchical model outlined earlier further limit their security.

The prospect (and, in some cases, reality) of competition among the regional networks which is inherent in the phase-out of NSF support is uncomfortable to the many regional networks which are tightly budgeted as it is. NSF does not intend the regional networks to have exclusive franchises for particular geographic regions -- nor could it because of antitrust problems. However, the amount of NSF subsidy may affect competitive standing: To the extent an individual regional is subsidized, it can offer connections at a lower price than an unsubsidized neighboring network. Even after the phase-out of NSF funding, the competitive benefits of an increased base of members or connections may linger.

Some regional networks also subsidized at the state or local level -- in some cases indirectly by state support for institutional connections or state networks (which, as noted, may connect to regional networks or serve as regional networks themselves). Some regional networks and state networks have benefited from close relationships with or grants from local exchange carriers or other telecommunications providers. This represents just the kind of leveraged support that NSF hoped to elicit in planning for mid-level networks, but it also breeds competitive imbalances that are not attributable to performance in the marketplace.

Because states are established political units with clear jurisdictional boundaries, some believe that the objective of leveraging the federal investment could have better been met by promoting state networks as the archetypical regional network. This would in theory result in a relatively clean and stable three-tier hierarchy well-suited to channeling political support and better insulated from some of the thornier problems of marketplace competition. However, as a consequence of NSF funding, the regional networks are well-established as the intermediate operating units in the Internet. The regional and other mid-level networks meet quarterly as an unincorporated association, the Federation of American Research Networks (FARnet), to discuss matters of common interest, although the diverse nature of FARnet's members, the lack of discretionary resources at the regional level, and the complexity of the policy environment have made concerted action difficult. Despite their continued growth, the regional networks are scarcely mentioned by the advocates of the National Research and Education Network.

Basic Pricing Structures

The cost of using the Internet through the regional networks is quite different from conventional communications utilities. In general:

-- **Network service is priced to availability rather than use.**

There are extraordinary economies of scale in optical fiber communications -- and excess capacity in the present market. For example, a T-1 line (1.544 Mbps) has 28 times the capacity of a 56 Kbps but only costs 4 or 5 times as much. Thus marginal costs for transmission needs above 300 Kbps are effectively zero -- at least up until 1.544 Mbps. Since (unlike the voice network) some uses, notably mail and lists, are not real-time, they can efficiently fill in between periods of peak use, thereby reducing overall capacity requirements. While unused capacity may represent wasted resources, it is offset by the advantages of fixed budgeting.

-- Network services are bundled into overhead at the institutional level.

Since there is no need to account for use at the institutional level, most user institutions simply treat network costs as indirect expense that is not charged out to individual users. This, of course, encourages individual use of the network and may lead to higher capacity lines in the future -- but it has positive of removing cost inhibitions for new users and increasing the visibility of the institution in the Internet community. It also furthers local concerns for equity among members of the academic community by ensuring that network connectivity is available to all campus users regardless of ability to pay.

-- As a consequence, there are no mechanisms for accounting for uses of specific network resources.

Without a chargeback system, there is no way of measuring transactions for special services that are not part of fixed fee network services. (Unlike local phone service, which can also as billing medium for toll calls and, now, gatewayed information services.) Accordingly, special services must be billed indirectly through conventional channels such as credit cards -- which looks like the commercial use that is typically prohibited as a matter of policy.

These same observations apply to BITNET, even though BITNET does not receive direct subsidies. Whereas commercial utilities, such as Compuserve, price exclusively to use -- and in a context where it is often unclear whether the resource is information, communications, or a time-sharing computer.[8]

As the costs processing power, communications, and information come down, more such services are priced to availability, simply because cost is increasingly keyed to availability. However, important exceptions will remain. Microcomputers represent an investment in availability, although at a certain level of size and sophistication, computers remain a scarce capital resource, the use of which must be accounted for directly -- whether by peer review or direct cost recovery. Since imaging and interactive use of remote supercomputers puts a great burden on network facilities (and since an accounting for use is already underway), it is widely assumed that such intensive, real-time uses of the network must incur special charges if overall network operations are to remain efficient.

At the other end of the spectrum, usage-based pricing may remain desirable for small users that cannot profitably use services priced to availability. In the case of network communications, the middle ground may shift around depending on the degree of excess capacity and the ability of vendors to aggregate customers on software-determined "virtual" leased lines. In the case of information resources, however, there are no fixed resources to be allocated, so the market must rely more on contractual and institutional solutions.

The Internet as an Information Environment

Dissemination of digital information is not limited to switched networks; it can also be broadcast by satellite, or stamped out on CD-ROMs, whatever is most efficient. As any and all of these technologies advance, the marginal cost of distribution approaches closer and closer to zero. Since, in contrast to network communications, short term capacity is not a limiting factor, there is no jumps in marginal cost (or deterioration in quality).

Since end-users have not had to bear communications costs, and since much dissemination of information has not imposed real-time demands on network capacity, the Internet and BITNET have become important conduits for non-proprietary information. The main constraint is the user's ability to process and manage the information he or she receives or has access.

There are nearly a thousand "lists" available to interested users over the Internet without charge. Some are simply mail exploders -- open asynchronous conferences -- in which comments sent to the list address are automatically mailed to all recipients of the list. Others are moderated; the messages are broadcast only after a human moderator has checked them for relevancy and, perhaps, determined that they are actually worth broadcasting. Others are digests, edited collections of comments, articles, and/or references mailed out on a periodic bases: electronic newsletters or journals. These different kinds of "lists" may be archived, so that past mailings can be retrieved on command, often even searched remotely by keywords.

An increasing proportion of network traffic is remote file retrieval[9], much of which is freely published information (for those who know how to find it). Readers of a particular list may be informed that a text is available as a public file access file, XXXX, at machine YYYY; this keeps the list mailings relatively small, a benefit for the user who must sort through mail in a linear fashion and less of a burden on the network itself. The reader would then access the remote machine using FTP ("file transfer protocol") and download file XXXX, which at the relatively high speeds of the Internet (typically 56Kbps versus 9.6Kbps for commercial packet-switched networks), usually only takes a few seconds.

Although there are a few conventions to be learned, once mastered the user is able to access a wide variety of information without paperwork or payment, whether it is delivered automatically as issued or by special request. Shells may be written for the users machine to further automate the process. Thus, because the computer environment trivializes the steps from citation to retrieval, the modal difference between dissemination of information and access to information is minimized.[10]

From a technical perspective, the Internet therefore holds a great deal of promise as an environment for electronic publishing. The real problem is how to make it work for "propriety" information -- that is, information which has production costs that must be recovered from users, whether the production and publication process is conducted by academics or commercial publishers.

This is partly a matter of controlling dissemination of the information. Weak security can be achieved through private mailing lists or by permitting FTP access only to certain addresses; strong initial security can be established through authentication systems such as Kerberos (developed by Project Athena at MIT). Redistribution must generally be inhibited by legal means -- contract or copyright. In general, these problems are substantially the same as in commercial systems -- only somewhat worse since the fact that access to the Internet is "free" to end users may facilitate unauthorized downloading and redistribution.

However, the immediate obstacle to dissemination of substantial resources on the Internet is uncertainty about what uses are permissible. The subsidized, non-commercial nature of the network suggests that only non-commercial uses should be permitted -- or at least only uses that do not substitute for services available in the private sector.[11] As noted, the draft NSFNET guidelines (see appendix) leave much uncertain, and the most of the regional networks that have adopted policies on appropriate use follow the NSFNET draft.

There are three principal dimensions to analyzing usage problems:

1.) PURPOSE: What uses are deemed acceptable? Can a publisher use the network for communicating with authors? For soliciting manuscripts? For invoicing? For delivering electronic journals? Since many commercial and quasi-commercial activities "support research and other scholarly activities," this common limitation of purpose needs further limitation.

2.) STATUS (of both provider and user): Who has access to the network? Can a commercial publishing enterprise connect to the network if it is not directly engaged in research? Can a publisher use the network to deal only with nonprofit clients, such as universities? Distinctions based on supplier status seem arbitrary and invidious since commercial and nonprofit entities often engage in similar publishing activities.

3.) PAYMENT STRUCTURE: What are acceptable methods for financing and cost recovery? Are direct charges keyed to unit of use acceptable? Although not commonly addressed in network guidelines, this appears to be an easy way of determining no direct competition since payment by units of use is the usual commercial practice.

Consider the following practices, all of which can be assumed to support scholarly research, but which mix elements of status and pricing structure:

a.) A consortium of universities packages information and delivers it to its members. (E.g., ICPSR)

b.) A consortium of universities acquires a database from a commercial vendor and mounts it on a mainframe for unmetered access by members of the consortium.

c.) A university-based project contracts with other universities to provided unlimited access to a database over the network for a fixed annual fee. (ARFTL at the University of Chicago)

d.) A consortium contracts with a commercial provider for unlimited access to database (for a fixed annual fee) to be delivered over the network from the provider's mainframe.

e.) A university contracts with a commercial provider for access over the network for a limited number of simultaneous accesses ("ports") at a fixed annual fee.

f.) A university contracts with a commercial provider for access time over the network at a volume discount.

g.) RLG (the Research Libraries Group) has recently made its RLIN bibliographic database available directly to individual end users over the Internet at a charge of $119 for a ten-hour block; the same ten-hour block delivered over Telenet costs $219. Should it make any difference that RLG is a nonprofit bibliographic utility operated by 38 of the largest research libraries -- rather a commercial publisher? From another perspective, it seems desirable that RLG should be willing to reach out beyond its library constituency to market directly to individual users.

These practices are in order of increasing commercial characteristics. In all cases, use of the Internet may substitute for access over Telenet, Tymnet, or Compuserve. But in the last two cases, time is metered just as it is in common commercial practice; hence this payment mechanism is nearly a direct substitute for services already on the market.

This structural distinction has been complicated by the recent emergence of CD-ROM as an alternative distribution path for commercial publishers -- one, which for budgeting and equity reasons, is very attractive to university libraries. Indeed, the CD-ROM is actually a variation of example e.) above, in which unlimited access through a fixed number of ports (one in the case of a single CD-ROM) is available for a fixed annual licensing fee.

Rationalizing Basic Network Services

Publisher acceptance of CD-ROM, while far from complete, is further evidence of competitive movement within the commercial sector toward availability-based pricing -- at least for large users. At the same time, within the regional networks, the planned phasing out of the federal subsidy necessitates cost-based pricing and therefore an unbundling into different payment structures.

Although basic network services on the regional are not priced to actual use, schedules have evolved to more accurately reflect costs. The schedule for newly organized New England Academic and Research Network (NEARnet) included in the appendix is a good example. NEARnet pricing includes four components:

1. Annual membership fee. This supports the administrative functions of the network, including the network information center (NOC). Typically, only nonprofit members are entitled to vote; for-profit members (and government agencies) pay substantially higher fees without a voice in the governance of the network. Some networks set a flat fee for each member class rather than a sliding scale as shown in the NEARnet schedule. In most cases, membership is a prerequisite for access.

2. Annual service fee. Because this fee is keyed to the size of the line, it is a charge for availability rather than access. It is designed to cover network operations (including the network operations center -- the NOC) with the line size presumably bearing a rough relation to the amount of use.

3. Annual leased line costs. This is born directly by the member as necessary to connect to the network's nearest point of presence. As more organizations connect to the network, the network itself will assume the costs of multi-user connections. This promotes efficiency by aggregating users on single circuits and obviating the need for continual negotiations among members

for joint use of lines as the network grows.

4. One-time installation costs. This is essentially the cost of installing the new node, regardless of where the new member is located. As the only one-time cost, it is like an initiation fee, and could be set to include one-time administrative costs as well.

While these services are not truly unbundled in the sense that one can pick and choose among, the rationalization is step toward unbundling where that may make sense.

This rationalized accounting is structurally significant in two respects. First, it paves the way for contracting network services to different entities, either by the regional network or by network members themselves. In many cases, NICs and NOCs are already run by profit-making entities. Experience may show that further subcontracting, perhaps to national organizations which perform the same function for different regional networks, makes sense.

Secondly, this rationalization also implicitly sets the stage for new optional services, including information services, which again may be performed by non-profit or for-profit entities. Conceptually, there is not a great difference between a commercial enterprise making a profit by operating a NOC and another enterprise making a profit by distributing bibliographic data.

If a regional network believes that a particular function can be handled better by an entity subject to market constraints but is reluctant to relinquish policy control or particular personnel, the network has the option of spinning off a for-profit subsidiary. The for-profit subsidiary can also be a vehicle for partnerships with companies that bring in needed expertise or resources.

Thus the role of the regional networks could change substantially from the original model of network management and operations. As multistate associations of universities involved in network activities, the regional networks can provide policy coordination, demonstration and evaluation of collaborative technologies, and clearinghouses for the marketing of new network services. Some may work to facilitate university-industry communication; others may concentrate on services to higher education. Some may choose to keep network operations in house and to investigate experimental uses of the network.

The several visions of the NREN -- the National Research and Education Network -- explicitly assume that network services will eventually become commercial services, but there is little to suggest how it will happen. It could conceivably happen overnight, but it seems more desirable that it happen as the particular need or occasion arises. The regional networks, if they do not adhere to preconceptions, can be the laboratories of appropriate transformation.

Notes:

(1) EDUCOM Networking and Telecommunications Task Force, "The National Research and Education Network: A Policy Statement," (EDUCOM: 1989); S. 1067, proposed as "National High-Performance Computer Technology Act of 1989," May 18, 1989; Executive Office of the President, Office of Science and Technology Policy, "The Federal High Performance Computing Program," 1989.

(2) Ken Klingenstein (chair, FARnet Policy Committee), "FARnet Policy Survey Response Summary," March 1, 1989.

(3) See, for example, Thomas I. M. Ho and Edward J. Tully, "Public Infrastructure Networks: the INdiana TELEcommunications NETwork case study," (1986?) INTELENET is oriented toward government and education (but not industry) and provides voice and video as well as data service. It gateways into CICNet (a regional network) through the University of Indiana.

(4) A. G. Fraser, "Opportunities and Obstacles for a National Research Network," EDUCOM Bulletin Vol. 23 No. 2/3, Summer/Fall 1988.

(5) There are presently few nameservers (the equivalent of telephone white pages) available over the networks, although there is much interest in providing such services within network information centers (NICs). However, the data would have to be gathered at the institutional level, which is difficult in highly decentralized research universities. Except in small centralized institutions, concerns about privacy and departmental autonomy are likely to keep the reporting of names and addresses voluntary.

(6) This dilemma creates some incentive to permit backdoor connections through network members. By handling only large, special purpose ("research") connections, the network looks less like a common carrier. It also avoids the administrative burden of dealing with many small accounts.

(7) Conceivably, transcontinental traffic could be routed entirely through interconnected regional networks, or the regional networks could establish their own national backbone. Compelled by accountability requirements in OMB Circular A-130, the FRICC, the interagency network coordinating committee, is pursuing "policy-based routing" that would enable prioritization of traffic on agency networks and backbones. However, implementation of policy-based routing is several years away.

(8) Compuserve has basic rate of $12.50 per hour for primetime access at 2400 baud. In addition, it levies a $.30 per hour charge for use of the Compuserve network -- a communications charge which does not apply if the access is through another network, such as Telenet. (However, Telenet charges are $12.00 per hour during the day.) Compuserve also has surcharges for

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(9) NSF Network Service Center, "The New NSFNET Backbone: One Year Later," NSF Network News, No. 6, July 1989, p. 1.

(10) This is a critical distinction in information policy. Dissemination of information concerns the publication of government generated information through GPO, NTIS, individual agencies, the Depository Library Program, and other mechanisms. Access to information refers to the Freedom of Information Act and related issues.

(11) See National Science Foundation, Notice 91, "Guidelines Related to the Use and Operation of National Science Foundation-Supported Research Instrumentation and Facilities."

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NSFNET BACKBONE - ACCEPTABLE USE POLICY

This statement represents a guide to the acceptable use of the NSFNET backbone. It is only intended to address the issue of use of the backbone. It is expected that the various middle level networks will formulate their own use policies for traffic that will not traverse the backbone.

(1) All use must be consistent with the purposes of NSFNET.

(2) The intent of the use policy is to make clear certain cases which are consistent with the purposes of NSFNET, not to exhaustively enumerate all such possible uses.

(3) The NSF NSFNET Project Office may at any time make determinations that particular uses are or are not consistent with the purposes of NSFNET. Such determinations will be reported to the appropriate NSFNET policy advisory group(s) and to the user community.

(4) If a use is consistent with the purposes of NSFNET, then activities in direct support of that use will be considered consistent with the purposes of NSFNET. For example, administrative communications for the support infrastructure needed for research and instruction are acceptable.

(5) Use in support of research or instruction at not-for-profit institutions of research or instruction in the United States is acceptable.

(6) Use for a project which is part of or supports a research or instruction activity for a not-for-profit institution of research or instruction in the United States is acceptable, even if any or all parties to the use are located or employed elsewhere. For example, communications directly between industrial affiliates engaged in support of a project for such an institution is acceptable.

(7) Use for commercial activities by for-profit institutions is generally not acceptable unless it can be justified under (4) above.

(8) Use for research or instruction at for-profit institutions may or may not be consistent with the purposes of NSFNET, and will be reviewed by the NSF Project Office on a case-by-case basis.

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NEARnet
New England Academic & Research Network

NEARnet FEE SCHEDULE
September 1, 1989

Annual Membership Dues

Member Class	Type	Annual Revenue/Budget	Dues Amount
University/ Non-Profit	Small	<$50M	$ 1,000
	Medium	$50-200M	$ 2,500
	Large	$200-500M	$ 5,000
	Very Large	>$500M	$ 7,500
Industry/ Government	Entrepreneurial	<$10M	$ 1,000
	Small	$10-50M	$ 5,000
	Medium	$50-200M	$10,000
	Large	$200M-1B	$15,000
	Very Large	>$1B	$20,000

Annual Service Fees

(These do not include leased line costs.)

Connection Data Rate	Service Fee
9.6Kb/s	$ 6,000
56Kb/s	$ 9,000
500Kb/s	$15,000
T1 (1.54 Mb/s)	$24,000
10 Mb/s	$36,000

Annual Leased Line Costs

NEARnet will provide purchasing services for leased telephone lines for member organizations. The options available and their costs will vary per member location.

One Time Installation Fees

Self Service Installation*:

Medium	Estimated Fee
9.6 Kb/s Leased Line	$13,500
56 Kb/s Leased Line	$13,000
500 Kb/s Leased Line	$20,500
T1 Leased Line	$20,500
10 Mb/s microwave	$50,000

*For full service installation add $2,500 to the self service fee.

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THE NEW ZEALAND SPECTRUM PROJECT: DESCRIPTION AND OBSERVATIONS

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and
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Prepared for
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Introduction

While many have long urged greater use of property right-based market systems to manage the use of the radio spectrum, such proposals have not been widely adopted. Currently, New Zealand is in the process of adopting such a property rights-based system to "manage" much of the radio spectrum in that nation. This paper describes the development of the market-based approach in New Zealand. The specific proposals for spectrum rights developed by National Economic Research Associates, Inc. (NERA) for the New Zealand government are described, the reaction of the New Zealand government to those proposals is described, and some specific observations on the project. This paper is written for those who have followed the debate in the United States over the use of market mechanisms to manage the spectrum resource, it assumes that the reader is familiar with the basic concepts of spectrum management and spectrum economics.

Background on New Zealand

New Zealand is an island nation in the South Pacific. It has a land area of approximately 100,000 square miles and a population of about 3.3 million. Its area and population roughly equal those of Colorado. The average population density is one fifth that of California. The nearest large nation is Australia, which is located about 1,000 miles to the west, across the Tasman sea. New Zealand is governed by a unicameral legislature under the parliamentary system.

Given these facts alone, we see that unlike European nations, or even the United States,[1] New Zealand is little constrained in its use of spectrum by the need to coordinate with its neighbors. We can also note that a population of 3.3 million can be expected to consume less radio-based communications than would a larger population. Thus, we can expect that New Zealand would have substantial unused spectrum and considerable freedom in planning the domestic use of such spectrum. Further, note that a nation this size can support relatively little research and development (R&D) on communications systems. For the most part, they will have to use radio technology developed and brought to market elsewhere in the world.

In 1984, the Labor party took office. It immediately instituted a program of economic reforms[2] which included the reorganization of several state-owned industries. One industry that was reformed was telecommunications which had previously been a monopoly function of the Post Office. Postal and telecommunications functions were separated and put into state-owned enterprises. The Post Office monopoly was to be phased out.[3] The spectrum management group was separated from the Post Office and was put in the Department of Trade and Industry. An inquiry was begun into the proper form of regulation for the spectrum. Given the strong pro-market bent of the current government, it is no surprise that serious consideration was given to the use of market-based spectrum management techniques.

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[1] Radio spectrum use in Detroit must be coordinated with use in directly adjacent Windsor. Generally, for frequencies above about 50 MHz, there is little radio propagation beyond the (radio) horizon, a distance of about 50 miles for a 1,000 foot high antenna.

[2] For a short but interesting partisan account of New Zealand's economic policy see "Douglas is Back but Rogernomics is Not" by Simon Upton which appeared in the Wall Street Journal, September 13, 1989, p. A21. Mr. Upton is a spokesman for the opposition National Party in New Zealand. See also the longer discussion in Keith Sinclair's, A History of New Zealand, Penguin Books, 1988 edition, pp. 320-330.

[3] As of April 1, 1989, New Zealand had completely deregulated telecommunications. Telecom (the carrier) is subject to no more formal economic regulation than are corner grocery stores or restaurants and there is open entry in all areas of telecommunications.

The NERA New Zealand Spectrum Study

In late spring of 1988, the Department of Trade and Industry issued a request for proposals for a consultant to study the use of radio spectrum in New Zealand and to recommend a spectrum management system. NERA won that competition, with a team consisting of NERA economists, and an outside attorney and engineer. The project manager was Robin Foster of NERA. Other NERA economists on the project team were Phillipa Marks and William Shew. Dr. Charles Jackson, then of Shooshan & Jackson Inc. was the engineer, and Robyn Durie of Linklaters and Paines was the attorney. The project team was assisted by NERA staff and by consultants Dr. Jeffrey Krauss and Dr. Molly Macauley. The project team was substantially aided by many in New Zealand to whom we owe our thanks. While the list of those in New Zealand who contributed to the project is too long to put here, we must give special thanks to Ian Hutchings of the Radio Frequency Service who was variously a sounding board, skeptic and cheerleader whenever one was needed.

The project's main objectives were:

1. To assess options which would maximize economic efficiency in use of the spectrum.

2. To evaluate and recommend practical and equitable options for the implementation of an allocation and management regime.

Project Recommendations

The project's major output was a 200-page report[4] recommending a mixed spectrum management system using traditional licensing for some parts of the spectrum (e.g., maritime mobile or CB) and property rights schemes for other regions (e.g., cellular or UHF broadcasting). A summary of that report follows:

Background

In New Zealand, allocation of the radio spectrum is managed, as in most other countries, by a centralized bureaucracy. Radio frequency management, which was a function of the New Zealand Post Office until its reorganization into commercial corporations on April 1, 1987, is now undertaken by the Department of Trade and Industry (DTI). The management functions are conducted by the Radio Frequency Service (RFS) in the name of the Secretary of Trade and Industry. The government, through the RFS, decides the general use to which various parts of the spectrum are to be put (e.g., FM sound broadcasting, land mobile), the geographic scope of individual spectrum licenses, the permitted levels of out-of-area and out-of-band interference, and the spectrum that is to be held in reserve for future potential uses. It also designates those parties who are authorized to use spectrum in conformity with the approved general use, territory and interference levels.

Concern that this centralized system of spectrum management and allocation would not perform well, in terms of its effect on economic efficiency, competition and social welfare, once barriers to entry into the telecommunications and broadcasting industry are removed and as demand for spectrum grows, motivated the Government to commission the investigation of alternative methods of spectrum management presented in this report.

In particular, the deregulation of the telecommunications and broadcasting industries on April 1, 1989, and future growth in demand for spectrum will mean that RFS will increasingly have to make choices between competing uses and users of spectrum. Our survey of existing and potential spectrum users and our assessment of demand trends suggest that, in the absence of price rationing, excess demand for VHF television frequencies, FM broadcasting, frequencies for mobile radio services (in particular areas, most notably Auckland), cellular telephone frequencies and some of the lower microwave frequencies could occur within the next 10 years. In the case of the cellular radio and VHF television frequencies, demand will come from competing users and some mechanism will be needed to choose between competing claims. Those television service providers who are not assigned use of VHF frequencies would be expected to seek UHF frequencies, which could result in the displacement of some amateur and aeronautical navigation use of these frequencies.

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[4] Robin Foster, et al., Management of the Radio Frequency Spectrum in New Zealand, NERA, London, 1988.

Expansion in the supply of FM sound broadcasting stations could, in the main urban area, use up all of the presently unoccupied FM frequencies and so lead to demand for frequencies in the upper half of the FM radio band, which are now fully used by mobile radio operators.

The Case For Market Allocation

Spectrum use can be determined by government regulation or by the operation of spectrum markets in which the government intervenes little or not at all. A fundamental difference between the two approaches is that decisions concerning the use of spectrum are centralized under a regime of regulation and are decentralized when individual users engage in free-market transactions among themselves.

In a market system, the rights to use spectrum in a designated way could be traded so that which party obtains a particular right is determined by who is willing to pay most for it, rather than the choice being made by an administrative process. In a parallel fashion, as long as spectrum rights can be geographically divided and aggregated, a market can determine whether the rights to use a frequency band are divided into many local rights or rights for a few large regions. Rather than the government controlling interference levels, they could instead be determined through private negotiations among the affected parties.

A market's most conspicuous advantage is that decentralization allows those parties who have the best information, the individual users, to make the decisions that determine spectrum allocation. For example, whether a channel would be of greater value if it is employed for FM sound broadcasting rather than land mobile communications can be difficult for an outside observer to assess; individual users, however, will have a good idea of how much the channel is worth to them and will disclose that value through the price they are willing to pay for the right to use it. In a similar fashion, allowing spectrum users to decide among themselves the patterns of interference that will be mutually permitted is attractive because users are likely to have a much better notion of the cost of interference on the one hand and the cost of abating interference on the other.

A market system would encourage the transfer of spectrum from lower-valued to higher-valued uses. It would allow use of spectrum to change in response to changes in technology[5] and consumer demand. If the price of spectrum rose or was expected to rise, reflecting an increase in demand relative to supply, this would encourage the use of spectrum-saving technologies. Spectrum managers would no longer need to make difficult choices (with inevitably limited information) about, for example, which of a number of competing television broadcasters should be allocated a particular frequency. The decision would be made in the market.

The advantages of a market system are tempered, however, by the consideration that a spectrum market could involve numerous bilateral negotiations. If the cost of individual transactions is high and there are numerous spectrum "neighbors" with whom negotiations are necessary, then efforts to achieve economically efficient interference patterns will be inhibited. The difficulties involved in designing market mechanisms which enable the efficiency gains to be realized while minimizing such transaction costs have, in part, inhibited the move towards market systems of spectrum management elsewhere in the world. Pressure from incumbent spectrum users reluctant to give up their valuable radio frequencies has also been important in preventing a more widespread application of market mechanisms to the management and allocation of spectrum.

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[5] In the UK, for example, it can take up to seven years to move existing users to make way for new technologies.

Proposed System of Spectrum Management and Allocation

In this report, we propose a system of spectrum management and allocation, based largely on tradable spectrum property rights, that is designed to take advantage of market mechanisms wherever there is good reason to consider that the resultant efficiency gains will be significantly greater than any potential increase in administration, transaction, and enforcement costs.

The choice of the definition of the spectrum property rights to be distributed is governed by these considerations. The specification of units of spectrum allocated through markets could range from tightly defined "spectrum products," specifying the location and use of a particular frequency, via "flexible spectrum products,"[6] to nationwide spectrum bands, for which there might simply be an overall limit on the power of out-of-band emissions. Because of the flexibility nationwide frequency bands give their owners in planning and potentially changing the use of spectrum, and because the implied internalizing of negotiations over spectrum use and interference disputes is likely to reduce transaction and enforcement costs, such spectrum bands seem preferable to more narrowly defined spectrum units.

However, much spectrum demand is for local use of particular frequencies and, if the spectrum band approach is to cater for this demand, nationwide band licensees will have to on-sell spectrum rights. These licensees could either be large end-users of the spectrum--who would be expected to buy bands of spectrum for their own use and on-sell or sub-license rights to use the spectrum they did not require (for example, providers of cellular telephone services)--or spectrum "intermediaries"--whose main function would be to plan and co-ordinate use of spectrum for on-sale or sub-license to smaller spectrum users.

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[6] By "flexible spectrum products," were refer to spectrum rights defined by reference to a specific transmitter, antenna location, signal power etc. These rights do not specify the end-use of frequencies.

To guard against the possibility that band licensees do not immediately supply spectrum matching the local demands of end-users, we propose that flexible local spectrum products should be created for initial distribution (by RFS) alongside nationwide bands. In the early years of its operation, therefore, the system will be characterized by a dual mechanism: private sector nationwide band licensees, acting as developers or intermediaries, alongside certain bands in which local flexible spectrum products or rights to specific fixed microwave links would be assigned (via competitive auction where necessary) by RFS (for example, rights to a spectrum product suitable for a local FM sound broadcasting station or a local land mobile service). Once the system is working well, the aim should be to "privatize" the RFS co-ordinated bands.

The centralized government spectrum management agency will have a diminished role in this new environment. Because of New Zealand's treaty and other international obligations RFS must, however, continue to be the body which represents New Zealand in international spectrum coordination and allotment negotiations. There is also a case for RFS or some other public body to maintain a register of spectrum assignments, and for public provision of interference detection/protection to households, subject to the condition that they make a payment for this service in order to discourage its frivolous use.

Our recommendations also include a continuing role for RFS to plan and co-ordinate the use of specific frequency bands throughout the spectrum. If it was thought that private sector management could perform these tasks more efficiently, RFS could subcontract them to a private firm. Similarly, if equipment authorization was retained it could either be carried out by RFS or a private firm.

At the start of the new system, "statements of interest" could be requested from prospective applicants for spectrum. Where there are competing demands for spectrum, licenses should be distributed by a (second-price) sealed bid auction. Auction winners should receive an immediate licence for their spectrum band, perhaps subject to the provision that any existing users will have a right (if they lose the auction) to match the highest bid. If such a right is not exercised, existing users should have a temporary three year right to continue their use. At the end of three years, the exclusive rights to such frequencies will be owned by the new band licensee. Existing users should be charged an annual fee to cover RFS's administration costs, and, if it is thought necessary for equity reasons, could be charged a "shadow price" for their frequencies.

Specific Recommendations

The recommendations given below set out a "robust" set of proposals which should work well notwithstanding the many uncertainties in advance of the introduction of a new market. These proposals address issues concerning the initial allocation of spectrum rights, the definition of rights, the enforcement of rights, and measures to deal with potential anti-competitive behavior. The proposals under each of these headings can be regarded as largely independent of each other. However, within each category the proposals are interdependent, and should be adopted as a package.

1. Distribution of Frequencies

Slightly different proposals are presented for the initial distribution and definition of spectrum rights for frequencies below 44 MHz, between 44 MHz and 3.6 GHz, and above 3.6 GHz. The differences in the proposals for these three parts of the radio spectrum are motivated by the different propagation and demand characteristics in each part of the spectrum, and by the differential effects of constraints imposed by New Zealand's international obligations.

Introduction of market mechanisms in the frequencies below 44 MHz, should be given a low priority, with the exception of the AM sound broadcasting frequencies which, it is proposed, should be auctioned as spectrum products. Potential efficiency gains in this part of the spectrum are lower than elsewhere, and international constraints on spectrum use limit the flexibility that a market could provide. In most of the region below 44 MHz, and elsewhere where the use of frequencies is constrained by international obligations, property rights should be retained by the Crown and managed by RFS, with the option left open of moving to a full system of private property rights at a later date.

Frequencies between 44 MHz and 3.6 GHz comprise the bulk of spectrum where there is likely to be excess demand for certain frequencies in the foreseeable future. It is here, therefore, that the greatest benefits from the introduction of market mechanisms could be achieved. To cater for local demand and gain the flexibility offered by nationwide frequency bands, a dual system of private sector nationwide frequency bands alongside some bands which would be retained by RFS for the distribution of local flexible spectrum products is proposed. For similar reasons, above 3.6 GHz we propose a system of nationwide bands alongside bands retained for RFS-led frequency coordination. Frequency coordination would involve the assignment of frequencies on a first-come, first-served basis unless there was more than one applicant for a frequency, in which case an auction would be held.

Proposal One: Distribution of Frequencies Below 44 MHz

For frequencies below 44 MHz, we recommend a continuation of the present method of spectrum management and assignment, with the exception of the AM sound broadcasting bands. The AM sound broadcasting bands should be auctioned as spectrum products defined by RFS. In the longer term, the case for market mechanisms in this part of the spectrum should be reviewed.

Proposal Two: Distribution of Frequencies Between 44 MHz and 3.6 GHz

We propose that the initial distribution of these frequencies should be in the form of both nationwide spectrum bands and local spectrum products. The result will be a dual system in which band licensees operate alongside the frequency bands retained by RFS for the formulation and auction of local spectrum products.

Proposal Three: Distribution of Frequencies Above 3.6 GHz

For frequencies above 3.6 GHz we propose that, in addition to the band licensing approach, some bands be reserved for frequency coordination to be carried out by RFS. Such frequencies would be assigned on a first-come, first-served basis with an auction only in the event that there are competing claims for a frequency. A tradable property right would be issued for each frequency assignment.

2. Spectrum Rights

The precise nature of the spectrum property rights to be distributed at the start of the new system has been determined, in part, by the desirability of reducing the risk that much initial costly re-contracting would be needed. It is proposed that the units to be auctioned should, where practicable, take the form of licenses for nationwide frequency bands. The width of such bands should be chosen to reflect current and likely future use of spectrum, and to reduce the number of boundaries where negotiations concerning out-of-band interference levels are needed. Limits on out-of-band interference should reflect the interference characteristics of current and likely future use of the frequencies within each band. Nationwide coverage is proposed to avoid the potentially costly negotiations over out-of-area interference limits that might be required if local or regional bands were specified.

If bands are sold only on a nationwide basis, however, the initial purchase of spectrum may be beyond the reach of many local end users, who will be obliged to acquire spectrum from the new nationwide band owners. To the extent that this causes problems of monopoly exploitation by band owners or results in very thin spectrum markets, one might wish to have some spectrum available on a local basis. Also, if it takes time for intermediaries or band licensees to enter the market selling use of frequencies on a local basis, it would be prudent to provide a safeguard against these outcomes in bands where they are most likely to occur (e.g., frequencies used by FM sound broadcasters or by land mobile operators). We propose RFS should create local "flexible spectrum products" for initial distribution by auction.

Within each frequency band, it is proposed that spectrum can be used for any purpose chosen by the band licensee, subject to the relevant interference default limits. Default limits determine the maximum permitted out-of-band (and out-of-area) interference associated with each spectrum property right. The default limits are intended to be used only if negotiation between spectrum users to establish preferred interference levels is unsuccessful, or should the cost of such negotiation be so high that it does not occur.

Spectrum rights can be aggregated or sub-divided, and re-contracting of the out-of-band interference levels will, no doubt, take place where it is perceived to be mutually advantageous. The duration of licenses should be long enough to give licensees the certainty they need to plan and obtain an adequate return on investment in spectrum using equipment. If fixed period, rather than perpetual, licenses are issued, then licenses for the next period should be auctioned sometime in advance of their commencement, in order to allow time for users to plan their future use of spectrum.

Proposal Four: Spectrum Rights

We propose that the initial units of spectrum to be determined should, as far as is practicable, take the form of frequency bands, which should be chosen to reflect existing New Zealand spectrum allocations and possible future demand. RFS should retain control over some bands.

Proposal Five: Flexible Spectrum Products

Where appropriate, some bands (i.e., those likely to be characterized by local use such as FM sound broadcast stations and mobile radio) should be planned by RFS to reflect the known local demand for frequencies, and then rights to local use of these frequencies (i.e., flexible spectrum products) should be auctioned.

Proposal Six: Definition of Default Limits

Default limits for the interference one user may cause to another should be set close to those interference levels given by the CCIR for the likely dominant end-use of a given block of spectrum. A tapered or flat field strength approach is feasible for out-of-band interference for both nationwide bands and spectrum products. For out-of-area interference, the choice should be between setting field strength limits in a defined area and a reference system approach, with our preference being for a reference system approach.

Proposal Seven: Duration of Spectrum Rights

On economic grounds alone, spectrum rights should be issued in perpetuity, although the efficiency loss associated with fixed period rights is likely to be small if rights for future periods are issued well in advance of the termination of the existing rights. If the government chooses to issue fixed period rights, these should take the form of a 20 year licence, with new licenses to be issued, via an auction, no fewer than five years in advance of the time they take effect.

Proposal Eight: Tradability

Spectrum licenses should be transferable, and capable of being subdivided and aggregated. This flexibility will enable licenses to be used for a variety of potential users, by the greatest number of possible users, and for their use to change.

Proposal Nine: Legal Definition of Rights

Spectrum property rights should be exclusive licenses. We would recommend a system of registration of spectrum property rights and of dealings in them similar to a land registry with the register being conclusive evidence of ownership and there being absolute title. Licence holders would be required to comply with New Zealand's international obligations, and any other conditions of the licence.

3. Transitional Arrangements

Some mechanism must be employed to accomplish the initial transfer of property rights from the government to users, and this must involve a device for rationing, since in some parts of the spectrum demand would outstrip supply if the government were to offer spectrum rights free on demand. Price-rationing, which is likely to transfer rights directly to the highest value users, is generally preferable to non-price rationing, which is likely to require subsequent exchanges in order to allocate the rights to their highest value use.

Because the government is not in a good position to predict what market clearing prices are likely to be, it is preferable to leave the determination of price to spectrum users, via an auction.

To avoid unnecessary auctions, and to reassure spectrum users that the aim of the new proposals is to achieve efficient spectrum allocation rather than raise revenue, consideration should be given to requesting "statements of interest" in each spectrum product or band before an auction is held. Only where there is more than one applicant for a given spectrum licence would an auction need to be held. To reduce the risk of collusion amongst bidders, a sealed bid auction is preferable to an open auction. The auction should be structured to encourage bidders to reveal their true value of spectrum. This is best achieved by assigning frequencies to the highest bidder who is then required to pay the second-highest bid price.

For reasons of equity, efficiency and to promote competition in downstream markets, existing users should be required to bid on a similar basis to new entrants. However, existing users will need to be given time after the auction to change equipment and purchase new frequencies, should they lose the right to the frequencies they now use.

During this transition period, we suggest existing users be given a temporary licence to continue using the frequencies they are now assigned. If it is considered essential to give incumbents some protection against losing their frequencies, then the option of allowing them to match the auction winning bid could be considered.

It seems unlikely that auctioning of frequencies in bands whose use is constrained by New Zealand's international obligations would yield any significant benefits--either in terms of efficiency gains or revenue--but would result in costs being incurred through users having to enter an auction. For these reasons we favor grandfathering of rights[7] in these bands, and to allow for the possibility that greater flexibility could yield efficiency gains, these rights should be tradable. Similar arguments apply in respect of the spectrum used by the Ministry of Defence.

Proposal Ten: Initial Transfer of Rights

The initial transfer of rights should, where necessary, use price to ration supply between competing demands. Because the government is not in a good position to predict what market clearing prices are likely to be an auction should be held.

Proposal Eleven: Form of the Auction

Auctions should be by sealed bids. The winner of the auction would be the entity offering the highest bid and the price paid for the frequencies auctioned should be the second-highest bid.

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[7] By grandfathering we mean giving current spectrum users the rights to the frequencies they now use free of charge.

Proposal Twelve: Existing Users[8]

Existing users of spectrum should be allowed to retain a temporary licence to use their current frequencies for an interim adjustment period of three years from the date of the auction. Temporary licenses should be tradable and the current user should be able to contract with band licensees for use of frequencies after the termination of the temporary licence. Charges should be made for temporary licenses based on the outcome of the auctions for full licenses, where this is likely to yield a significant net benefit. If it is considered necessary to give existing users further protection against losing their frequencies, consideration should be given to including a "matching bid" option in the auction process, by which incumbents would be allowed to reenter the auction and match the winning bid, possibly with an additional premium.

Proposal Thirteen: Internationally Determined Distribution

Where international agreements largely determine the use of frequencies, as in the case of aeronautical, marine and satellite applications,[9] the users should be "grandfathered" their spectrum at no cost with subsequent freedom to trade. If they can, in the future, benefit financially from economizing in spectrum use this might encourage them to do so. If there is no obvious band licensee, RFS should continue its function as a planner and co-ordinator of these frequencies.

Proposal Fourteen: Ministry of Defence

If, following further assessment of the future needs of commercial spectrum users, RFS identifies significant potential demand for spectrum currently held by the MOD, consultations should be held with the MOD to examine ways of releasing some of the spectrum for commercial use. One option would be for the MOD to release selected frequencies (of its own choice) for auction at an early stage, subject to conditions of use reflecting any strategic considerations.

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[8] Excluding the Ministry of Defence.

[9] ISM, radio astronomy, space research and internationally agreed amateur bands would also be included.

4. Enforcement Mechanism

Existing legal remedies do not deal with all types of frequency interference problems. In particular, they do not cover the case of "lawful" interference, when, for example, two frequency right holders exercise their rights in accordance with the terms of their licence, but create unexpected interference. In this instance, negotiation between the parties with ultimate appeal to the courts in cases of non-compliance and with equal sharing of costs, would appear to be a suitable means of resolving disputes. If, however, there is no technical solution to the problem, then the second in time right holder could be required to cease the activity causing the interference.

As existing tort remedies have not been used previously to prevent or provide compensation for harmful interference, it would be desirable to provide new civil remedies in the legislation for both unlawful and "lawful" interference for the sake of certainty and comprehensiveness. This would enable the creation of expertise in this area by an administrative body or the courts dealing with all types of interference problems. It would avoid the confusion that could arise by applying tort concepts developed in different circumstances to a new and complex situation.

Court-based enforcement of rights is recommended in preference to either tribunals or arbitrators because courts can act quickly to stop interference (via an injunction), can more easily deal with a multiplicity of parties and, through their contempt powers, can ensure compliance with their decisions. In an area as technical as radio interference, the court could be given power to sit with lay members.

Proposal Fifteen: New Statutory Torts

We propose three new statutory torts (or duties). The first is a statutory duty on the part of spectrum right holders not to operate outside the parameters of their licenses, which can be enforced by other right holders and by the Crown. The second is a statutory tort of nuisance which can be used by receiver owners in the event of interference to their reception. A third statutory duty not to emit signals in a particular part of the spectrum without holding a licence to do so is also proposed, to enable right holders to obtain compensation in respect of damage from unauthorized transmitters.

Proposal Sixteen: "Lawful" Interference

When two (or more) frequency right holders exercise their rights in accordance with the terms of their licenses, but create unexpected interference, the parties should negotiate a solution to the problem with the costs being borne equally by the parties involved. If no technical solution to the problem is possible, then the "second-in-time" right holder could be required to cease the activity causing the interference.

Proposal Seventeen: Adjudication by Courts

Adjudication should be by the courts alone. The appropriate part of the court system would be the Administrative Division of the New Zealand High Court, together with the appointment of technically qualified lay members. Injunctions should be available without proof that damages are an adequate remedy, as in many cases it will be difficult to prove and quantify damages satisfactorily.

Proposal Eighteen: Enforcement Role for RFS

Consideration should be given to RFS retaining an enforcement role to protect small spectrum users and also to act in exceptional circumstances, such as breach of New

Zealand's international obligations. Furthermore, equipment authorization procedures should be retained under any new system, though the details of procedures will need further investigation. Equipment testing could either be carried out by RFS, as at present, or by a private organization contracted by RFS.

Proposal Nineteen: Annual User Fee

Under the new management system, users should pay an annual fee to RFS in accordance with the cost to RFS of providing them with services such as spectrum management, interference enforcement, etc.

5. Competition Issues

Present New Zealand competition law, under the Commerce Act of 1986, is designed to deal with the possibility of an organization misusing a dominant position in product or service markets. This law would also apply in respect of ownership of a certain set of radio frequency spectrum rights and using that position to harm competition in other related markets. Consideration is being given by government to reinforcing the essential facilities doctrine in the Commerce Act to preclude the misuse of exclusive spectrum property rights. To reduce the risk of anti-competitive practices in the spectrum market and associated downstream markets, consideration should also be given to the inclusion of statutory power in new spectrum management legislation for the setting of specific guidelines limiting the extent of sole ownership of frequencies used for particular applications, such as cellular radio and VHF television.

Proposal Twenty: Prevention of Anti-Competitive Behavior

To reduce the risk of the spectrum market and associated downstream markets being susceptible to anti-competitive practices, we propose that:

(i) Consideration should be given to including a statutory description of the essential facilities doctrine in the legislation creating the spectrum property rights, together with a right to order a sale of frequencies at market value.

(ii) If (i) is considered to be insufficient to prevent anti-competitive behavior or it the government wishes to promote competition in specific markets, then we would propose that the legislation creating the spectrum right should give the government the right to impose conditions on the auction or other conditions limiting the amount and nature of spectrum rights to be acquired by one firm.

(iii) Sale of local protect licenses should be used to give potential access to spectrum to small users. Likewise, a frequency coordination system should be used alongside band licenses in spectrum above 3.6 GHz.

6. Proposed Timetable

The period during which the new system is introduced should be relatively short--we suggest 18 months--with the frequencies to be auctioned announced at the start of the process, in order to give prospective users time to formulate their plans and understand how the market is likely to work. Priority in the early months should be given to an RFS sponsored programme of education, and the implementation of a registration system and an enforcement mechanism.

We propose that in the first six months (after the passing of the necessary legislation) priority should be given to auctioning frequencies for which demand is likely to be greatest, namely cellular and other UHF frequency bands, and the FM radio frequencies. Also, to ensure frequencies are available for fixed links and other applications complementary to cellular radio and broadcasting, bands suitable for these applications should be either made available or planned by RFS at an early stage, and the frequency coordination system for spectrum above 3.6 GHz should be put in place. Simultaneously, incumbent users will need to be issued with temporary product licenses to run for three years from the date of the relevant band auction.

At the start of 1990, we propose that AM radio products and two of the bands presently used for land mobile should also be auctioned. UHF land mobile and some fixed bands should also be auctioned at this time. All remaining bands should be auctioned three months later, around mid-1990, and band or product licenses (whichever is appropriate) issued to users constrained by international obligations. The final step will be to auction the VHF television frequencies towards the end of 1990, although disposal of these rights could be given a higher priority if this was thought necessary to facilitate the successful deregulation of television broadcasting.

New Zealand's Implementation of the Recommendations

The project's final report was delivered to the client in November 1988. Shortly after that[10] the cabinet decided to move forward along the general lines of the NERA recommendations. Legislation was drafted during the spring and summer of 1989. On August 17, 1989, a radio communications bill was introduced into the New Zealand Parliament. That bill would establish a spectrum management regime that allowed for the sale, leasing, mortgage, and other market-based transactions for spectrum rights governing much of the spectrum. Appendix A contains an outline of that bill, as introduced.

The bill was formally open for public comment until September 14, 1989. At the time of this writing, it appears highly likely that the bill will be enacted with only minor modifications.

Observations on the Project and Proposals

While proposals for the increased use[11] of market techniques in spectrum management have been made for several years, there have been few prior attempts[12] to develop a comprehensive market-based system and there has been no prior proposals of the specificity and scope of those developed through the NERA report and the legislative drafting. Several general observations can be drawn from this process which may be helpful to future policy analysts.

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[10] The authors are unaware of the exact date of the cabinet decision. They believe that it was near the end of January 1989.

[11] While economists have long urged increased application of market techniques to the management of the spectrum, it is only in the last decade or so that there has been a growing recognition that some traditional spectrum management practices incorporate substantial market driven decision-making. Most notable among these is the frequency

Scope. It was immediately apparent to the project team that there were few benefits from applying market management techniques to many parts of the spectrum. For example, the frequencies used for maritime mobile or aeronautical mobile communications in New Zealand are the same way internationally and variance by New Zealand from such international norms would not make economic sense nor would it comport with New Zealand's treaty obligations. Similarly, auctioning off the CB band seems silly. Thus, NERA proposes a mixed system, continuing a licencing system for some parts of the spectrum and a property rights system for other parts. Naturally enough, radio amateur use of the spectrum fell into the non-market sector.

Duration of rights. The NERA report supports perpetual rights (essentially fee simple rights), but suggests 20-year "leases" as a fall back. The draft legislation chose 20-year terms for the spectrum rights. While perpetual rights can always be bought back by the Crown or seized by eminent domain, there was a view that totally severing the Crown's rights was going one step to far. This view was reflected in NERA's fall back recommendation and the government's choice in drafting legislation.

Lack of geographic boundaries. The NERA report recommends that spectrum be auctioned off in either of two units--nationwide band licenses (e.g., the rights to transmit

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coordination in terrestrial microwave. The FCC's recent approval of cellular flexibility is another example of the partial use of market forces.

[12] Most notable are the Tempo study by DeVany et al. and the recent efforts in the UK. Legislative proposals in the United States have proposed giving the FCC broad authority to implement market tools, but these proposals do not specify market mechanosms.

throughout the band 494-522 MHz throughout New Zealand) and what we call "product licenses" (e.g., the right to transmit a TV signal at 1 MW eirp, omnidirectional, from a 1,000 foot tower at a specific location). We did not recommend any intermediate spectrum units such as the TAS units suggested by DeVany et al. Our analysis of the market for such geographically restricted rights convinced us that the need for localized rights could be better met by having the Crown retain ownership of a band and to auction off individual station licenses inside that band.

The Horrible Inter-modulation Problem. Anyone who has ever discussed the use of market-based spectrum management with skeptical professional spectrum management people will recall the crowning argument of such professionals "How do you control inter-modulation products?"[13] Some other interference problems, e.g., the problems caused by local oscillator radiation, have similar characteristics. The NERA report proposes to deal with such problems by encouraging resolution through negotiation, but, if such resolution is technically impossible, creating a preference for the first user in time. Thus, operation of a specific system under a broad general right would create a further property right in the employment of the broader right. In essence, a small amount of claim-staking or first-come, first-serve rights allocation was recommended.

While professional spectrum managers were skeptical of this approach, none were able to shoot any holes in it.

Views of Professional Spectrum Managers. The project team had many meetings with professional spectrum managers working in the New Zealand government, explaining, defending, refining and improving the NERA recommendations. We believe that, by the end of the project, we had convinced many of these professionals, but not all, that the market-based system embodied in the NERA proposals would work reasonable well--at least on a par with traditional management techniques.

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[13] Intermodulation products are created whenever signals two frequencies (say F_1 and F_2) pass through a non-linear circuit. The non-linearities cause radio energy to appear at frequencies of the form $|kF_1 \pm jF_2|$ where j and k are integers. Thus, if $F_1=100$ MHz and $F_2=100.100$ MHz, then there can be interfering energy at 100.200 MHz ($2F_2-F_1$) or 99.900 MHz ($2F_1 - F_2$).

The draft legislation incorporates safeguards, such as requiring that a radio engineer certify that property rights transactions, such as sub-dividing a band, will not create unlawful interference. This section of the legislation reflects more the view of traditional spectrum managers and radio engineers[14] than of economists. But it should impose little cost, while offering assurance to all that the new system is no riskier than the old.

Transitional Issues. (The NERA recommendation.) The project team was divided over the proper treatment of existing radio licensees.[15] Some felt that existing operations and licensees[16] should be essentially totally grandfathered--vested with property rights in their current operations. Others felt that, wherever possible, existing operators should vie with newcomers for the access to the spectrum. To the extent that existing operators had sunk costs, they would reflect the economic value of those sunk costs in their bids, and efficiency would be served.

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[14] When this section was explained to the NERA team, some thought it was a reasonable precaution, while others felt it was a legal and economic monstrosity.

[15] Compared to the U.S., the radio spectrum is relatively lightly used in New Zealand. Below 500 MHz the pattern of use is somewhat similar to that in the U.S., including a VHF-TV band and a large government band from 230-400 MHz. Between 500 and 800 MHz, the spectrum is essentially vacant, a cellular system is operating in the 800 MHz region, and microwave and satellite systems are lightly used above 1,000 MHz.

[16] The existing licensees who occupied most of the spectrum were Broadcasting Corporation (BCNZ), which operated two nationwide VHF-TV services, a nationwide microwave system, and ENG systems, Telecom, which operated a nationwide microwave system, a cellular system, and many land-mobile systems. Both BCNZ and Telecom are state-owned enterprises--that is corporate organizations with a board of directors but whose common stock is owned by the Crown. A third nationwide television service, to be operated by a private firm, TV 3, was authorized in late 1988. Clearly, auctioning off Crown resources to Crown corporations does little to serve the revenue or equity goals that auctions might serve in other circumstances.

The project report compromises between these two positions, though it makes many accommodations to the grandfathering view. In particular, the recommendations on division of the spectrum into bands to be auctioned off, follow the band divisions currently used in New Zealand. Hence, incumbents would be able to bid for bands that matched their operations well. Similarly, the NERA report did not recommend that the spectrum used by the Ministry of Defense (MOD) be auctioned. The report waffled between recommending that the TV frequencies be sold off in three packages corresponding to the three current services and recommending that the TV spectrum be sold off as band licenses.[17] However, the report recommended that, while incumbents (except MOD) would be allowed a grace period of three years during which they could continue operating, they be required to bid for their current spectrum along with others.

The Legislative Resolution. We understand that developing workable transitional arrangements were a difficult part of the legislative drafting process. The proposed legislation gives the existing television broadcast operations a grace period of at least eight years. Public safety, some non-commercial and Maori broadcast operations were exempted from the auction process. The TV band is to be auctioned off in packages of licenses corresponding to the packages of licenses held by the three current operators. Existing incumbents are allowed to enter the auction late, after all bids have been opened, and to win by matching the highest bid.[18]

For existing land mobile frequencies, essentially all of which are operated by Telecom as a consequence of the prior Post Office monopoly, the legislation recognizes that, for many systems (e.g., a radio system serving a taxi company), while Telecom is the licensee, the real incumbent is the taxi company, and that an auction procedure which gave a preference to the incumbent licensee, would not serve efficiency. Thus, the legislation does not allow land mobile to have the incumbent protection seen elsewhere.

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[17] See Management of the Radio Frequency Spectrum in New Zealand (November 1988), Ministry of Commerce, pp. 178-179. Compare with table on p. 180.

[18] This option was suggested in the NERA report as a method of giving incumbents protection while still allowing the economic efficiency of auctions. If the incumbents are uncertain about the value of their existing licenses or are differentially reluctant to reveal the value of those licenses (as compared to new entrants), then this alternative probably serves efficiency.

In every case but one, land mobile, those drafting the legislation moved away from the NERA recommendations and towards more complete grandfathering. Further, transitional issues were a difficult part of the drafting process.

The political situation in New Zealand was probably as favorable as possible in a Democratic state towards being able to impose a no-grandfathering solution. It has a parliamentary system and all the major licensees were organizations of the state nominally under the control of the cabinet. There was much vacant spectrum, hence the scarcity value of existing licenses was small. Nevertheless, by the time legislative drafting was completed, grandfathering was almost total.

Conclusions

No final conclusion can be offered for many years. However, it appears highly likely that a spectrum management system based in large part on transferable, subdividable property rights can be implemented in a democratic state. We now have (almost) an existence-proof where specific proposals for such a system were able to withstand both intellectual and political arguments against their implementation.

New Zealand was very much a special case for the following reasons: (1) its limited prior use of the spectrum; (2) its geographic isolation; (3) its sudden need, arising out of the elimination of the Post Office monopoly, for a spectrum regulatory system; (4) the nature of politics in a parliamentary democracy; (5) the commitment by the cabinet to market solutions, (6) the presence of senior staff in the bureaucracy similarly committed to market solutions; and (7) the lack of any large pool of existing licensees in the private sector.

Few of these conditions will hold in most other developed countries, many may hold in lesser developed countries. Similarly, it may be easier to move to a market-based spectrum management system in socialist nations, such as Poland, which are attempting to move their economy generally closer to market solutions and where there is currently little or no private use of radio systems, than in well developed countries which have already licensed many non-government users.

APPENDIX A

RADIOCOMMUNICATIONS BILL

INTRODUCTION SPEECH

30

HON JONATHAN HUNT (MINISTER OF BROADCASTING):

I MOVE THAT THE RADIOCOMMUNICATIONS BILL BE READ A FIRST TIME.
THIS BILL IS THE FINAL MAJOR LEGISLATIVE MEASURE TO IMPLEMENT THE GOVERNMENT'S TELECOMMUNICATIONS AND BROADCASTING POLICY REFORMS WHICH WERE ANNOUNCED LAST YEAR.

THE UNDERLYING AIMS OF THOSE REFORMS - AS WITH THIS BILL - ARE TO

- ACHIEVE GREATER CONSUMER CHOICE AND ECONOMIC GROWTH IN TELECOMMUNICATIONS AND BROADCASTING SERVICES

  AND

- TO PROMOTE SOCIAL POLICY OBJECTIVES IN THOSE SECTORS MORE EFFECTIVELY.

THE GOVERNMENT'S DECISION TO PERMIT COMPETITION IN TELECOMMUNICATION NETWORK SERVICES WAS IMPLEMENTED ON THE FIRST OF APRIL THIS YEAR, BY THE TELECOMMUNICATIONS AMENDMENT ACT 1988.

MAJOR CHANGES TO THE STRUCTURE OF BROADCASTING WERE IMPLEMENTED UNDER THE BROADCASTING CORPORATION OF NEW ZEALAND RESTRUCTURING LEGISLATION, ENACTED LATE LAST YEAR, AND THE BROADCASTING ACT 1989, WHICH CAME INTO FORCE ON THE FIRST OF JULY.

THESE REFORMS, AS FORESHADOWED IN THE GOVERNMENT'S ANNOUNCEMENTS LAST YEAR, AND DURING PASSAGE OF THE AMENDMENTS TO TELECOMMUNICATIONS AND BROADCASTING LEGISLATION, ALSO REQUIRE THE REFORM OF THE PRESENT LEGISLATIVE MANAGEMENT REGIME FOR RADIO SPECTRUM.

USE OF THE RADIO SPECTRUM IN NEW ZEALAND IS PRESENTLY CONTROLLED THROUGH AN ADMINISTRATIVE, FIRST COME, FIRST SERVED LICENSING SYSTEM. ALTHOUGH THE SYSTEM IS PRESENTLY CONSTITUTED UNDER PART II OF THE TELECOMMUNICATIONS ACT 1987, IT REFLECTS MANAGEMENT PRACTICES FIRST ESTABLISHED MANY YEARS AGO.

THE EFFECTIVENESS OF THIS SYSTEM HAS BEEN DEPENDENT ON THE CONTINUED EXISTENCE OF THE LEGISLATIVE MONOPOLY IN TELECOMMUNICATIONS SERVICES, WHICH WAS PREVIOUSLY ENJOYED BY TELECOM CORPORATION OF NEW ZEALAND LIMITED; AND WARRANT RESTRICTIONS ON BROADCASTING SERVICES, ADMINISTERED BY THE BROADCASTING TRIBUNAL.

APART FROM THESE LICENSEES, RADIO FREQUENCY USAGE HAS BEEN DOMINATED BY GOVERNMENT AGENCIES.

THE SYSTEM IS UNSUITED TO A MORE OPEN COMMERCIAL ENVIRONMENT IN WHICH THERE ARE COMPETING DEMANDS FOR SPECTRUM, AND A CORRESPONDING NEED TO ENCOURAGE ECONOMIC EFFICIENCY IN SPECTRUM USAGE.

A SYSTEM WHICH ALLOWS THE DELAYS AND FRUSTRATIONS EVIDENT IN THE PREVIOUS INSTITUTIONAL ARRANGEMENTS FOR BROADCASTING, IS NO LONGER ACCEPTABLE.

THE GOVERNMENT WANTED A SYSTEM WHICH WOULD BE CONDUCIVE TO THE INTRODUCTION OF NEW SERVICES AND TECHNOLOGY.

ACCORDINGLY, IN DECEMBER 1988 THE GOVERNMENT ANNOUNCED ITS ADOPTION IN PRINCIPLE OF THE RECOMMENDATIONS OF NATIONAL ECONOMIC RESEARCH ASSOCIATES OF LONDON, WHICH WERE COMMISSIONED IN 1988 TO CONDUCT AN IN DEPTH REVIEW.

THE MAIN FEATURES OF THOSE PROPOSALS HAVE BEEN INCORPORATED IN THIS BILL WITH CONSIDERABLE REFINEMENT.

THE FINAL LEGISLATIVE PROPOSALS ALSO TAKE INTO ACCOUNT EXTENSIVE CONSULTATIONS WITH ALL THE MAJOR FREQUENCY USER GROUPS.

THE RESULTING BILL ADDRESSES TODAY'S NEEDS THROUGH THE ESTABLISHMENT OF A NEW SCHEME OF LEGAL RIGHTS, WHICH WILL FACILITATE COMMERCIAL DEVELOPMENT OF THE TELECOMMUNICATIONS AND BROADCASTING MARKETS.

AT THE SAME TIME THE LEGISLATION, TOGETHER WITH OTHER GOVERNMENT MEASURES, PROVIDES A MORE EFFECTIVE FRAMEWORK FOR PUBLIC SAFETY, DEFENCE, SECURITY, NON-COMMERCIAL BROADCASTING USES, AND SOCIAL AND RECREATIONAL USES.

AS INDICATED BY ITS SIZE, THIS BILL OF 151 CLAUSES PROPOSES A FUNDAMENTAL REORGANISATION OF RADIO FREQUENCY MANAGEMENT IN NEW ZEALAND.

THE KEY FEATURES OF THE NEW LEGISLATIVE REGIME CONTAINED IN PARTS ONE TO SIXTEEN ARE AS FOLLOWS:

> RIGHTS TO SPECTRUM USE WITHIN DEFINED RADIO ENGINEERING PARAMETERS WILL BE CREATED IN THE FORM OF MANAGEMENT RIGHTS, WITH A DURATION OF UP TO 20 YEARS.
>
> THESE RIGHTS ARE ACCORDED CERTAIN ATTRIBUTES OF PROPERTY UNDER THE BILL, INCLUDING THE RIGHT OF TRANSFER, AGGREGATION OR DIVISION, AND USE AS FINANCIAL SECURITY.
>
> ALL ORIGINAL MANAGEMENT RIGHTS ESTABLISHED WILL BE REGISTERED IN THE NAME OF THE CROWN, ACTING THROUGH THE SECRETARY OF COMMERCE.
>
> THE CROWN AS HOLDER OF THE ORIGINAL RIGHTS, OR OTHER PERSONS TO WHOM MANAGEMENT RIGHTS HAVE BEEN TRANSFERRED, WILL BE CALLED MANAGERS.
>
> THEY MAY CONFER LICENCES ON OTHER PERSONS FOR USE OF THE MANAGEMENT RIGHTS, WITHIN THE PRESCRIBED PARAMETERS OF THOSE RIGHTS.
>
> THE EXERCISE OF BOTH MANAGEMENT AND LICENCE RIGHTS IS CONSTRAINED BY STATUTORY OBLIGATIONS AND MINIMUM STATUTORY CONDITIONS, PRIMARILY DESIGNED TO AVOID RADIO INTERFERENCE.
>
> IN ADDITION TO ENFORCEMENT BY THE SECRETARY OF COMMERCE AGAINST CONTRAVENTIONS OF THE BILL, THE BILL PROVIDES FOR PRIVATE LEGAL REMEDIES FOR THE PROTECTION OF RIGHTS, INCLUDING NEW ACTIONS IN TORT AND FOR DAMAGES.

A FORMAL SCHEME OF REGISTRATION IS ESTABLISHED FOR THE RECORDING OF DETAILS OF MANAGEMENT RIGHTS AND LICENCES, AS WELL AS OTHER TRANSACTIONS SUCH AS TRANSFERS, AGGREGATIONS AND MORTGAGES AND CAVEATS.

VERY HIGH STANDARDS FOR RECORDING OF TRANSACTIONS AND ENGINEERING CERTIFICATIONS ARE REQUIRED UNDER THE BILL, TO UNDERPIN THE INTEGRITY OF REGISTRATION.

THIS IS ESSENTIAL TO THE ORDERLY DEVOLUTION OF MANAGEMENT RIGHTS, AND EFFECTIVE TRADING IN SPECTRUM RIGHTS.

THE GOVERNMENT HAS ALREADY ANNOUNCED THAT IT PROPOSES TO EFFECT TRANSFER OF SPECTRUM RIGHTS, BY WAY OF TENDER, WHERE COMMERCIAL DEMAND EXCEEDS SUPPLY OF AVAILABLE SPECTRUM.

IT HAS ALSO STATED THAT

- THE USE OF SOME FREQUENCIES IS CONSTRAINED BY INTERNATIONAL CONVENTION OR AGREEMENT, AND TYPICALLY WILL REQUIRE MANAGEMENT BY THE CROWN DIRECTLY.
- PRIORITY WILL CONTINUE TO BE GIVEN TO THE RESERVATION OF FREQUENCIES FOR DEFENCE, SECURITY AND PUBLIC SAFETY USES BY GOVERNMENT AGENCIES, WHICH WILL IN MOST INSTANCES REQUIRE DIRECT CROWN MANAGEMENT.
- SPECTRUM WITH LIMITED USE OR DEMAND, OR REQUIRING COMPLEX INTERNATIONAL COORDINATION, IS NOT EXPECTED TO BE TENDERED.

THE BILL IS SUFFICIENTLY FLEXIBLE TO ENSURE ADEQUATE PROVISION FOR THE ALLOCATION OF FREQUENCIES FOR NON-COMMERCIAL USES, IN ACCORDANCE WITH GOVERNMENT POLICIES.

SPECIAL PROVISION HAS BEEN MADE FOR TRANSITIONAL PURPOSES.

ALTHOUGH PART TWO OF THE TELECOMMUNICATIONS ACT 1987 IS REPEALED BY THIS BILL, EXISTING LICENCES ARE CARRIED OVER UNDER PART THIRTEEN OF THE BILL.

SUITABLE PROVISIONS FROM THE FORMER ACT HAVE BEEN INCORPORATED INTO PART THIRTEEN OF THE BILL, TO ALLOW THE TRANSITION TO BE BOTH PRACTICAL AND PROGRESSIVE.
THESE WILL ALLOW FOR A STEADY AND ORDERLY TRANSITION TO THE NEW REGIME, EXPECTED TO LAST FOR UP TO FIVE YEARS.

THE GOVERNMENT HAS ALREADY APPROVED AN INDICATIVE TIMETABLE OF PRIORITIES FOR BRINGING FREQUENCIES UNDER THE REGISTRATION SYSTEM.

NEW SERVICES OF CONSIDERABLE COMMERCIAL AND CONSUMER SIGNIFICANCE ARE ACCORDED PRIORITY.

A NUMBER OF KEY AREAS OF SPECTRUM WILL BE OPENED UP OVER THE NEXT YEAR.

I AM PARTICULARLY PLEASED TO SAY THAT ADMINISTRATIVE WORK TOWARDS THE OPENING UP OF UHF TELEVISION SERVICES IS WELL ADVANCED.
THE GOVERNMENT HAS PAID VERY CAREFUL ATTENTION TO ESTABLISHING EQUITABLE TRANSITIONAL ARRANGEMENTS FOR EXISTING RADIO APPARATUS LICENCE HOLDERS.

THE GOVERNMENT IS NOT, HOWEVER, PROVIDING MECHANISMS TO PROTECT INDIVIDUAL BUSINESSES FROM COMPETITION.

IT IS WELL KNOWN THAT SOME OF THOSE WHO HAVE GAINED ACCESS TO RADIO FREQUENCIES, THROUGH THE GRANTING OF WARRANTS AND STATUTORY MONOPOLY PROVISIONS RESPECTIVELY, MAINTAIN STRONG VIEWS THAT THEY ARE ENTITLED TO LONG TERM PRESERVATION OF ALLOCATED RADIO FREQUENCIES.

THE GOVERNMENT DOES NOT AGREE WITH CLAIMS THAT ANY SUCH ENTITLEMENT EXISTS.

IT DOES RECOGNISE, HOWEVER, THAT CONTINUED STABILITY AND GROWTH IN TELECOMMUNICATIONS AND BROADCASTING MARKETS DEPEND ON FAIR ARRANGEMENTS FOR EXISTING LICENSEES.

THE ARRANGEMENTS PROVIDED FOR WILL LIMIT DISRUPTION, AND PROVIDE A HIGH LEVEL OF ASSURANCE FOR BUSINESS INVESTMENT.

ACCORDINGLY, SPECIAL PREFERENCES FOR EXISTING LICENSEES HAVE BEEN DETAILED UNDER PART SIXTEEN OF THE BILL, WHICH ELABORATE THE PRINCIPLES OF INCUMBENT PREFERENCE ALREADY ANNOUNCED BY THE GOVERNMENT.

THEY ARE INCLUDED IN THE BILL ITSELF, IN ORDER TO PROVIDE CERTAINTY AS TO THE SPECIFIC ARRANGEMENTS WHICH WILL APPLY TO SIGNIFICANT AREAS OF CURRENT USAGE.

UNDER THIS PART OF THE BILL, ALL INCUMBENTS WILL HAVE THE RIGHT TO CONTINUE THEIR OPERATIONS FOR A MINIMUM OF THREE YEARS WITHOUT RENTAL, UPON ANY TRANSFER OF MANAGEMENT RIGHTS.

LICENCE FEES WILL COVER THE GOVERNMENT'S ADMINISTRATIVE COSTS.

BROADCASTING SERVICES

UNDER CLAUSES 130 TO 134, COMMERCIAL BROADCASTERS WILL HAVE PREFERENTIAL BIDDING RIGHTS TO ACQUIRE FREQUENCIES IN WHICH THEY HAVE HELD LICENCES, BY MATCHING AND PAYING THE HIGHEST BID IN ANY TENDER.

IN ADDITION TO THE TRANSITIONAL RIGHTS MENTIONED ABOVE, THE PACKAGES OF FREQUENCIES REQUIRED FOR EACH OF THE PRESENT VHF TELEVISION SERVICES ARE EACH TO BE TENDERED AS A COMPLETE PACKAGE, AND AT THE SAME TIME.

THIS RECOGNISES THE TECHNICAL COMPLEXITY OF THE EXISTING INFRASTRUCTURE, AND THE UNDESIRABILITY AND IMPRACTICALITY OF ANY MAJOR CHANGES IN THIS AREA.

THE GOVERNMENT HAS ALREADY ANNOUNCED THAT TENDERING FOR THE PRESENT TELEVISION BANDS WILL NOT OCCUR UNTIL 1994, ALLOWING TV3 AT LEAST FIVE YEARS FOR ESTABLISHMENT.

THE NORMAL TRANSITIONAL RIGHT OF INCUMBENCY FOR THREE YEARS WILL STILL APPLY AFTER THE DATE OF ALLOCATION BY TENDER.

CELLULAR RADIO SERVICES

UNDER CLAUSES 135 TO 138, TELECOM, ALTHOUGH NOT HOLDING ALL POSSIBLE LICENCES IN ONE OF THE TWO MOBILE TELEPHONE SUB-BANDS, WILL BE TREATED,

FOR THE PURPOSES OF EXERCISING TRANSITIONAL RIGHTS, AS HAVING THE USE OF THAT WHOLE SUB-BAND.
THIS IS CONSISTENT WITH THEIR PRESENT EXPECTATIONS AND INTERNATIONAL PRACTICE.

TELECOM'S THREE YEAR INCUMBENCY RIGHT WILL ALSO PROVIDE-FOR REASONABLE EXPANSION OF BUSINESS WITHIN THE SUB-BAND.

TELECOM WILL ALSO BE ABLE TO MATCH AND PAY THE HIGHEST BID IN ANY TENDER RELATING TO THAT SUB-BAND.

LAND MOBILE SERVICES

FREQUENCIES RELATING TO TWO FREQUENCY LAND MOBILE OPERATIONS PRESENT PARTICULAR DIFFICULTIES IN ESTABLISHING THE PROPER INCUMBENT.

THEREFORE THE MATCHING BID PROVISION PROVIDED UNDER CLAUSES 139 TO 145 IS NOT AVAILABLE IN SOME CIRCUMSTANCES.

THIS IS TO PREVENT A USER EFFECTIVELY BIDDING AGAINST THEMSELVES, THROUGH THE PROXY OF THE TELECOM CORPORATION.

PUBLIC SAFETY USES

THE BILL MAKES SPECIAL TRANSITIONAL PROVISIONS FOR RECOGNISED PUBLIC POLICY USES UNDER CLAUSES 149 TO 150 RESPECTIVELY.

THE GOVERNOR-GENERAL IN COUNCIL MAY SPECIFY FREQUENCIES WHERE TENDERS WILL NOT BE REQUIRED, ON ACCOUNT OF THE NEED TO PRESERVE NATIONAL SECURITY AND PUBLIC SAFETY ASSIGNMENTS.

NON-COMMERCIAL AND SOME EXISTING MAORI STATIONS SPECIFIED IN THE SEVENTH SCHEDULE HAVE BEEN EXEMPTED FROM COMPULSORY TENDER, AND ARE GRANTED LICENCES DIRECTLY WHICH CORRESPOND TO PREVIOUS ARRANGEMENTS.

TRANSFERS OF THESE LICENCES WILL REQUIRE CONSENT IN ORDER TO MAINTAIN THE INTENDED SPECIAL CHARACTER OF THOSE LICENCES.

OTHER MAIN FEATURES OF THE BILL ARE AS FOLLOWS:

POWERS OF REGULATION ARE BEING RETAINED TO PROVIDE FOR MINIMUM STANDARDS OF EQUIPMENT, TO LIMIT INTERFERENCE, AND FOR A REGIME OF APPROVING EQUIPMENT.

BACK UP POWERS OF REGULATION, FOR THE STANDARDISATION OF RADIOCOMMUNICATIONS SYSTEMS AND FORMATS IN NEW ZEALAND, ARE ALSO INCLUDED IN THE BILL.

THE PROHIBITIONS AGAINST ANTI-COMPETITIVE CONDUCT CONTAINED IN THE COMMERCE ACT 1986, AS WELL AS THE MERGER AND TAKEOVER CONTROLS, APPLY TO FIRMS ENGAGED IN TELECOMMUNICATIONS AND BROADCASTING SERVICES.

CLAUSE 125 INTRODUCES A NEW CONTROL OVER THE ACQUISITION OF SPECTRUM AND SUBSEQUENT SPECTRUM TRANSFERS, WHERE SUCH TRANSACTIONS WOULD RESULT IN DOMINANCE IN ANY OF THE INDIVIDUAL SERVICE MARKETS IN TELECOMMUNICATIONS OR BROADCASTING.

LIMITS ON OVERSEAS OWNERSHIP OF BROADCASTERS WERE INTRODUCED IN THE BROADCASTING ACT 1989.

AS ALREADY ANNOUNCED IN THE GOVERNMENT'S BROADCASTING POLICY DECISIONS, TV3 WILL BE REQUIRED, AS A CONDITION OF ITS CONTINUING RADIO LICENCE, TO ADHERE FOR THREE YEARS TO THE UNDERTAKINGS IT GAVE TO THE BROADCASTING TRIBUNAL.

THIS IS PROVIDED FOR IN CLAUSE 151 OF THE BILL.

THAT IS A SUMMARY OF THE MAIN FEATURES OF THE BILL.

I ALSO WISH TO RECORD TO THE HOUSE THAT THE GOVERNMENT HAS DECIDED, IN ACCORDANCE WITH THE TREATY OF WAITANGI PARTNERSHIP, TO CONTINUE WITH CONSULTATIONS WITH THE NEW ZEALAND MAORI COUNCIL, THE WELLINGTON MAORI LANGUAGE BOARD, AND OTHER MAORI REPRESENTATIVES, ON ISSUES RELATING TO THE MANAGEMENT REGIME FOR RADIO SPECTRUM.

MR SPEAKER, THIS IS AN INNOVATIVE MEASURE, WHICH WILL ATTRACT CONSIDERABLE INTEREST AND COMMENT.

IT DEALS WITH COMPLEX RADIO ENGINEERING, LEGAL AND ECONOMIC ISSUES.

THE FRAMING OF THE BILL NEVERTHELESS DRAWS SUBSTANTIALLY ON SOUND PRINCIPLES AND EXPERIENCE IN SPECTRUM ALLOCATION, PROPERTY LAW AND ECONOMIC MANAGEMENT.

THE GOVERNMENT WILL ADOPT A PRUDENT AND CAUTIOUS ADMINISTRATIVE APPROACH TO THE DEVOLUTION OF SPECTRUM RIGHTS UNDER THE BILL WHEN ENACTED.

THE GOVERNMENT IS CONFIDENT THAT THE FRAMEWORK IS SUFFICIENTLY FLEXIBLE AND ROBUST TO MEET BOTH THE COMMERCIAL AND NON-COMMERCIAL NEEDS OF THE COMMUNITY.

I INTEND TO MOVE THAT THIS BILL BE REFERRED TO THE PLANNING AND DEVELOPMENT SELECT COMMITTEE FOR CONSIDERATION.

I COMMEND THIS BILL TO THE HOUSE.

Office of the
MINISTER OF BROADCASTING
Wellington New Zealand

EMBARGOED UNTIL INTRODUCTION OF THE RADIOCOMMUNICATIONS BILL
IN THE HOUSE

PRESS STATEMENT
HON JONATHAN HUNT
MINISTER OF BROADCASTING

HON DAVID BUTCHER
MINISTER OF COMMERCE

AUGUST 17TH

RADIOCOMMUNICATIONS BILL: MAIN HIGHLIGHTS

1. **A new radio spectrum management regime.**
   The new allocation system, based on a formal registration scheme, replaces the present first-come first-served licensing system.

2. **A new scheme of legal rights.**
   This involves the creation of management and licence rights to spectrum use, within parameters, with a duration of up to 20 years.

3. **Rights to spectrum use will be fully tradeable.**
   They will also have certain attributes of property, including right of transfer, aggregation or division and use as financial security.

4. **The exercise of spectrum rights will be constrained.**
There will be minimum statutory conditions designed to avoid radio interference.

5. **There will be Comprehensive private legal rights of remedy where contraventions occur.**
This includes actions in tort and damages.

6. **There will be new competition rules applied to radio spectrum management.**
These will counter anti-competitive conduct and any monopolisation of spectrum.

7. **Special arrangements for access to spectrum have been arranged for certain groups.**
These include non-commercial broadcasters and those using it for public safety, defence and security purposes.

8. **The provision of transitional arrangements for existing users.**
These include 3 year incumbency rights and pre-emptive rights.

ENDS

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Office of the
MINISTER OF BROADCASTING
Wellington New Zealand

17 August 1989

EMBARGOED UNTIL INTRODUCTION OF RADIOCOMMUNICATIONS BILL
IN THE HOUSE

JONATHAN HUNT, MINISTER OF BROADCASTING

RADIOCOMMUNICATIONS BILL:
TV3 PROGRAMMING CONDITIONS

The Minister of Broadcasting, Hon Jonathan Hunt, today confirmed that under the Radiocommunications Bill, TV3 will be required to fulfil programming undertakings made by its member companies when seeking broadcasting warrants.

The Bill requires TV3 to make Maori interests and concerns a prominent element in its programming and presentation, and in its third year it must broadcast not less than 52 hours of programmes specifically designed to interest Maori people.

TV3 is also required to meet targets over its first three years of 26.5%, 36.5% and 37.9% New Zealand programme content or programmes specifically targeted at a New Zealand audience.

"These measures, which apply until 31 December 1992, carry out decisions announced in August 1988, as part of the Government's broadcasting policy review, to hold TV3 to its undertakings for a reasonable transitional period," Mr Hunt said.

"Voluntary undertakings concerning Maori and New Zealand programming helped TV3 obtain its television warrants against strong competition from other applicants. TV3 is now able to use VHF spectrum for television broadcasting, a considerable advantage over other new television broadcasters, who will be required to tender and pay for UHF spectrum later in 1989. Broadcasting costs are generally lower on VHF spectrum."

TV3 will not be faced with tendering for its VHF spectrum until 1994," Mr Hunt concluded.

(ENDS)

For more information, contact Diane Moir, Press Secretary, Telephone 719 821 or 719 995.

THE TOTAL AND PARTIAL FACTOR PRODUCTIVITY OF THE NIPPON TELEGRAPH AND TELEPHONE CO.

by

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THE TOTAL AND PARTIAL FACTOR PRODUCTIVITY OF THE NIPPON TELEGRAPH AND TELEPHONE CO.

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ABSTRACT

Productivity can be used to evaluate the effects of new technologies, regulatory reform, and changes in organizational strategy and structure. In the past, considerable effort has been devoted to measuring, analyzing and interpreting the changes in factor productivities for telecommunications industries in the U.S., Canada, Germany and other OECD countries. However, relatively little work has been devoted to measuring the productivity of the Japanese telecommunications industry. The purpose of this paper is to provide basic productivity measures for NTT, the dominant provider of telecommunication services in Japan.

In this paper we present total and partial factor productivity measures for NTT for the period 1971-1987. During that time period, NTT's TFP level increased at an average annual rate of 2.5%. However, productivity growth improved at a significantly faster rate during the most recent four or five years; an average annual rate of 4.2% for the 1983-87 is observed as compared to a 1.93% average growth rate for 1971-83. NTT's TFP growth rates are compared with previous findings for the dominant telecommunication providers in the U.S., Canada, and West Germany; however, rigorous comparison of productivities across firms in different countries will require more transparent data and further analysis.

THE TOTAL AND PARTIAL FACTOR PRODUCTIVITY OF THE NIPPON TELEGRAPH AND TELEPHONE CO.

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Hajime Oniki, Tae H. Oum and Rodney Stevenson

I. INTRODUCTION

The purpose of this paper is to provide basic productivity measures for NTT, the dominant provider of telecommunications services in Japan. Although there have been many productivity studies of the major telecommunication firms in the United States, Canada, Germany and other OECD countries, little work has been devoted to measuring the productivity of firms in the Japanese telecommunications industry.

NTT is briefly described in section II. In section III we discuss the methods of productivity measurement. Total and partial productivity measures of NTT for the 1971 - 1987 period are presented and discussed in section IV. Concluding comments are provided in section V. An explanation of data construction and sources is provided in an appendix.

II. NIPPON TELEGRAPH AND TELEPHONE CO.

NTT is the largest corporation in Japan, and the largest telecommunication corporation in the world. With over 48,000,000 telephone subscriber lines and some 600,000 leased circuits, NTT's services and products include local and long distance telephone, telegraph, leased circuit, digital network, paging, telex, and other services. In 1987 NTT had ¥=5,345 billion in revenues, 290,000 employees, and assets of ¥=9,811 billion. Income before income taxes was ¥=358 billion, and net income was ¥=243 billion.

NTT has grown substantially over the period 1971-1987, as shown in Tables 1.1-1.6. Total revenues grew at an average annual rate of 9.64% and telephone subscription grew 6.39% per year. The average annual growth rates of assets, employment and material and supply usage were 6.79%, 2% and 8.18% respectively.

Prior to 1985 NTT was a state run monopoly responsible for all domestic telephone service and under the regulatory oversight of the Ministry of Posts and Telecommunications (MPT). In 1985 NTT was privatized, steps were taken to introduce competition into the telecommunications market, and the regulatory authority of MPT was enhanced. Privatization and the introduction of competition occurred, at least in part, because of concerns about NTT's productive efficiency.

III. PRODUCTIVITY MEASUREMENT

Our analysis of NTT's productivity is based on the neoclassical theory of production. We assume that the firm's production function is given by:

1] $h(\underline{Q},\underline{Z}) = 0$

where Q is a vector of outputs and Z is a vector of inputs. Productivity measures the firm's ability convert inputs (such as capital, labor, and materials) into outputs (such as telephone service). We define total factor productivity (TFP) and partial factor productivity (PFP) as an output-input ratio:

2] $TFP = Q^*/Z^*$

$PFP = Q^*/Zi$

where Q^* is an aggregator function of outputs, Z^* is an aggregator function of inputs, and Z_i is the i^{th} input (Z_i may be an aggregator function of inputs of the i^{th} type such as different categories of labor or capital).

Improvements in TFP can benefit the firm through greater profits, the consumer through price reductions, and society in general through the 'release' of resources of production. The benefits of PFP improvement is not as transparent; improvement of the partial factor productivity of one input may simply represent the uneconomic over-utilization of another input.

The TFP and PFP instantaneous growth rates are given by:

3] $\dot{TPF} = \dot{Q}^* - \dot{Z}^*$

$\dot{PFP} = \dot{Q}^* - \dot{Z}^*$

The instantaneous growth rates of aggregate output and aggregate input are given by the respective Divisia indices:

4] $\dot{Q}^* = \Sigma_j ((p_j q_j)/R)\dot{q}_j$

and

5] $\dot{Z}^* = \Sigma_i ((w_j z_j)/C)\dot{z}_i$

where p_j is the j^{th} output quantity, R is total revenue ($\Sigma_j\ p_j q_j$), w_i is the i^{th} input price, z_i is the i^{th} input quantity, C is total cost ($\Sigma_i\ w_i z_i$), $\dot{q}_j$ and $\dot{z}_i$ are the instantaneous growth rates of the j^{th} output and the i^{th} input price, respectively.

For data that are available only for periodic intervals (such as yearly), a discrete time approximation to the Divisia index must be used to aggregate the outputs and inputs. The discrete time approximations of productivity improvement may be represented as:

6] $TFPI_{t,t-1} = (Q^*_t/Q^*_{t-1})/(Z^*_t Z^*_{t-1})$

$PFPI_{t,t-1} = (Q^*_t/Q^*_{t-1})/(Z_{i,t}/Z_{i,t-1})$

Although many alternative methods for the discrete time approximation are proposed in the literature, the Törnqvist approximation procedure is most widely used because of its desirable properties as an indexing procedure (see Diewert, 1976 for details). The Divisia approximations for output and input growth rates are given by:

7] $Q^*_t/Z^*_{t-1} = \exp[\Sigma_j \frac{1}{2}(r_{j,t} + r_{j,t-1})\log(q_{jt}/q_{j,t-1})]$

and

8] $Z^*_t/Z^*_{t-1} = \exp[\Sigma_i \frac{1}{2}(r_{i,t} + r_{i,t-1})\log(z_{it}/z_{i,t-1})]$

where t denotes the time period, $r_{j,t}$ is the revenue share of the j^{th} output $(p_{j,t}q_{j,t}/R_t)$, and $s_{i,t}$ is the cost share of the i^{th} input $(w_{i,t}z_{i,t}/C_t)$.

IV. PARTIAL AND TOTAL FACTOR PRODUCTIVITIES

A. Outputs and Inputs

In order to compute total and partial factor productivities, an aggregate output index and input indexes for each of three inputs, labor, materials, and capital, are constructed. The data and aggregation methods are described in the data appendix.

Tables 3 through 5 report various data used to compute output and input indexes. With regards to output and revenue growth, NTT's 1987 revenues were 4.4 times the 1971 level. Approximately two-thirds of the revenue growth is attributable to an increase in output; the remaining one-third reflects increases in price. Remarkably, most of the price increase during this period occurred in 1976 and 1977 after first petroleum shock. After 1977, price increases are negligible, rising at an average annual rate of only 0.4%; during the recent four year period (1983-87), price of output decreased at an annual rate of -1.16%.

Aggregate input data are reported in Table 4. Total cost increased approximately 3.7 times during the period of 1971 to 1987. The average annual rate of increase in input quantity for this period is 4.2% and that in input price is 5.7%. The annual rate of increase in aggregate input steadily decreased until 1985, whereas the input price changes fluctuate greatly.

Table 5 shows the relation of the index of each of three inputs (labor, materials, and capital) to the aggregate input index. During the 1970s, labor input increased steadily; during the 1980s it decreased steadily. Labor input in 1987 is only 2% higher than that in 1971. Materials input increased by 60% from 1971 to 1987. Labor and materials inputs together constitute about one-half of the aggregate input, with the remaining half being the capital input.

Capital input in 1987 is 3.8 times its level in 1971. Interestingly, however, the annual rate of increase in capital input steadily decreased during the period of 1971 to 1987. Prior to 1977, the rate of increase in capital input exceeded 10% per year, during the second half of the 1970s, the rate was between 5% and 10% per year, and after 1981, it was less than 5%. The lowest rate of increase in capital occurred in 1987 at 1.1% per year.

During the period of 1971-87, the average annual rate of increase is slightly above 10% for both labor cost and wage rate though the rate of increase in the labor input is practically zero. The rate of increase in labor cost steadily decreased during this period. Materials cost increased at an annual rate of 8.2% during the period of 1971-87, of which 5.1% is attributed to increase in materials price.

The capital service input is constructed from the data of gross investment (equipment, cables, and others). Capital input increased steadily at annual rate of 8.7% for the period of 1971-87. The rate of increase is high during the first half of 1970s; the annual rate of increase declined steadily since 1978.

B. NTT Total and Partial Productivity

Partial factor productivities for labor, materials, and capital are computed by dividing the output index by each of these inputs respectively. Total factor productivity is derived by dividing aggregate output by an aggregation of the two inputs. The results are reported in Tables 1 and 2.

During the 1971-87 period, the NTT's TFP increased from a normalized level of 1.00 to 1.49, an average annual increase of 2.5%, as reported in Table 1. During this period, the average annual rates of increase of aggregate output and aggregate input are 6.9% and 4.2% respectively.

During the 1971-87 period, as shown in Table 2, labor and materials productivities have increased at average annual rates of 6.7% and 3.8%, respectively, while the productivity of capital input has declined at an average annual rate of 1.7%. This implies that a large part of the increased labor productivity was possible due to capital investment for automation and technological advancement. The negative growth rate of capital PFP suggests the possibility of uneconomic over-capitalization.

The rate of productivity growth varied during the 1971-1987 period, showing significant improvement for the most recent years. TFP grew at an average annual rate of 4.3% during the most recent four year period (1983-87) as compared to the 2.0% average growth per year during the 1971-83 period.

Until 1977, when the demand for telephone subscription was fully saturated and automatic dialing service was extended to all telephones, the average annual growth rates for outputs and inputs were high-10.5% and 7.1%, respectively. During the following six year period (1977-83), which includes the worst post-war economic recession, outputs and inputs continued to grow, but at lower rates of 4.4% and 3.6%, respectively. TFP improvement reached its lowest growth rate during this period, averaging only 0.7% per year.

Annual rates of change in TFP, output, input fluctuate substantially during the 197-87 period. The rate of growth of input decreases during this period and is negative in 1985. On the other hand, though the annual rate of increase in output tends to decline through 1981, it increases after that. The recovery of the rate of increase in output may be explained by the introduction of new services that were made possible by recent technological progress.

Labor productivity improved at a somewhat greater rate during the 1983-87 period as compared to the 1971-83 period, 7.5% per year as compared to 6.5%. What is most interesting is that during the 1983-87 period the capital productivity grew at an average annual rate of 2.9%, though it was negative over the 1971-83 period (-3.2% per year). Capital productivity declined the most during the 1971-77 period (-4.5% per year), and it was relatively low at -1.9% during the remaining period (1977-83). This implies that the increase in capital productivity after 1983 implies that the NTT's capital program may have been rationalized after realizing that the regulatory reform and privatization would soon occur.

The importance of TFP growth can be seen by reference to Table 6. Following Sollow (1957), the growth rate in output can be represented as follows:

9] $$\dot{Q} = \dot{TPF} + S_l\dot{L} + S_k\dot{K} + S_m\dot{M}$$

where $\dot{L}$, $\dot{K}$, and $\dot{M}$ are the growth rates of labor, capital and materials, and S_l, S_k, and S_m are the cost shares of labor capital and materials, respectively. Thus, output growth can be accounted for through growth in TFP and growth in labor, capital, and materials. As indicated in the Table 6, during the period of 1972-87, TFP contributed 51% of output growth and capital input 42% of it. During the most recent four years (1983-87), the average contribution of TFP to output growth reached a high of 78% of output growth.

TFP and PFP improvements occur for a number of reasons. Productivity improvement (as we have measured it here) may represent the realization of economies of scale, scope, or utilization. Productivity improvement also occurs because of improved managerial control, technological progress, or improved quality of the inputs. Beginning in the early 1980s, NTT was preparing for the transition of its operation from one of monopoly to the forthcoming competitive era. The Japanese Diet approved the Telecommunications Business Law and the NTT Corporation Law in December, 1984 and NTT was incorporated as a private company in April, 1985. Obviously the recommendation by the Committee for Administrative Reform (July, 1982) and Cabinet approval of the administrative reform guideline (September, 1982) had signalled for the forthcoming privatization and increasing competition in the industry. This may well have had effect on improving efficiency of NTT's operations starting as early as 1983.

C. Tentative cross-country comparisons

As stated previously, comparison of the level of TFP across different countries would require more detailed information for linking the output and input indices. The data currently available to us do not allow such a direct comparison of TFP levels across countries. In the absence of the absolute comparison, the next best alternative is to compare the growth rates of TFP across countries.

Fuss and Waverman (1981) report an average annual TFP growth rate of 4.45% during the 1970-76 period for Bell Canada while Nadiri and Shankerman (1986) report a 3.5% improvement per year during the 1968-76 period for AT&T. Crandall (1989) reports a 2.7% annual TFP improvement rate for AT&T for 1976-1977 and a 3.8% rate for 1977-1987. This compares with 3.1% TFP growth per year for NTT during the 1971-77 period. NTT's TFP growth rate does appear to be somewhat low as compared to those of Bell Canada and AT&T during the first part of 1970s, though NTT's TFP level did improve significantly since 1983 (TFP growth rate was 4.2% per year during the 1983-87 period).

Cross-Country Comparison

Firm	Average Annual Productivity Growth Rate	Source
NTT	TFP 2.5% (71-87)	Oniki/Oum/Stevenson (1989)
NTT	TFP 3.1% (71-77)	
NTT	TFP 4.2% (83-87)	
Bell Canada	TFP 4.45% (70-76)	Fuss/Waverman (1981)
AT&T	TFP 3.5% (68-76)	Nadiri/Schankerman (1986)
AT&T	TFP 2.7% (67-77)	Crandall (1989)
AT&T	TFP 3.8% (77-87)	Crandall (1989)

V. SUMMARY AND CONCLUDING REMARKS

In this paper we have presented total and partial factor productivities for NTT. For intertemporal or cross-country comparison of the effectiveness in converting valuable capital, labor, and materials into telecommunication services, productivity measures are preferable to profitability or relative revenue measures. Profitability and measures such as revenue per employee may reflect more about the prevailing regulatory and market conditions than the efficiency of production.

Our productivity measures suggest a significant improvement in NTT productivity during the most recent time period. The growth in TFP should ideally be decomposed by source in order to tell more clearly how productive and managerial efficiency have been improved by the introduction of competition and privatization. This requires a more extensive data set. For example, our sample period must be expanded to go back at least to 1961. TFP should also be measured by each functional or service unit of the NTT. This would help evaluate how the performance of a certain functional division has changed over time, particularly since the privatization.

The current study does not allow for a well formed comparison of the TFP performance across firms in different countries. In order to make such an inter-country comparison of TFP levels, it is necessary to create multilateral indices for inputs, outputs and factor productivities. This requires the data series which allow for transparent comparisons across the firms in different countries such as AT&T, Bell Canada, British Telecom, etc.

DATA APPENDIX

(1) Aggregate Output

Seven categories of revenues are included in the annual reports of NTT: toll charge and fixed charge for telephone subscriptions, charge for public telephones, charge for private lines, telegrams, telexes, and miscellaneous charges. Our output measure is based on the seven outputs corresponding to these revenue categories.

The quantity of toll output is computed by dividing toll revenue with its price, which was compiled from a list of unit toll charges. The price of fixed charge is set equal to the sum of fixed and miscellaneous charges per subscriber, which is obtained from NTT's annual reports. The quantity of fixed charge component is the ratio of the fixed charge revenues to the fixed charge price. Public telephone quantity is obtained by dividing public telephone revenue with the price of public telephone toll charges. NTT has set unit charges for public telephones at the same level as for toll calls, local and long distance.

The quantity of private lines is calculated by dividing private line revenue with its price, also compiled from tables of private line charges. We set telegram output equal to the number of telegrams serviced, and telex output to the number of telex subscriptions. The prices of these outputs are obtained by dividing revenues with quantities, respectively. Finally, quantity of miscellaneous charges is the ratio of miscellaneous revenue to the implicit GNP deflator.

The aggregate output quantity index was then computed by applying the Törnqvist-Theil index number procedure to the seven outputs. The aggregate output price index was computed by dividing the total revenue by the output quantity index.

(2.1) Generation of real capital stock series:

Our method of treating capital inputs is based on Christensen and Jorgenson (1969). We begin by following the perpetual inventory method to generate the real capital stock series for each of the three categories of capital assets: equipment and circuits, buildings, and other equipment.

(1) $K_{j,t} = (1 - \delta_j)K_{j,t-1} + I_{jt}$,

where $K_{j,t}$ is the computed capital stock of asset j, $I_{j,t}$ is gross investment in asset j, and δ_j is the rate of depreciation of asset j, t denoting a time period. We used the following as values for depreciation rates:

j	δ_j (per year)
Equipment and circuits	0.10
Buildings	0.04
Other equipment	0.15

In addition to the three assets, we also include land and intangible assets, so that the total number of asset categories is five. The quantity of land and intangible assets was estimated by deflating their book values obtained from NTT's annual reports. Total capital stock is obtained by adding up the five capital stock series.

(2.2) Calculation of Service Prices of Capital Assets

The following formula is used for computing the service price (economic cost of using one quantity unit) of capital stock. The formula is a straightforward adaptation of the Hall-Jorgenson (1968) and Christensen-Jorgenson (1969) procedure to the NTT situation where there is no income tax obligation (prior to the 1985 privatization) and thus no need to take into account the investment tax credit rate:

$$(2) \quad W_{jt} = b_t W_{j,t-1} + \delta_{jt} V_{jt} - (V_{jt} - V_{j,t-1}) + T_t V_{jt}$$

where W_{jt} is the user cost of capital type j, i.e., the price of capital service), V_{jt} is the price of investment good of asset j, b_t is the rate of return to a riskless bond, and T_t is the property tax rate for fixed assets.

Note from this formula that the user cost of capital consists of opportunity cost of capital, depreciation, capital gain/loss and local taxes (mainly property taxes). Note also that since NTT was not subject to corporate income tax for most of our sample period, 1971-87, the original formula proposed by Christensen and Jorgenson (1969) was modified in order to reflect that. This formula was applied to each of the five asset categories.

The price of equipment and circuits is constructed by combining the wholesale price indexes for telecommunication equipment and communication cables, reported by the Bank of Japan. The price of buildings is the composite price index for construction works of non-residential non-wooden buildings, reported by the Ministry of Construction. For other equipment, land, and intangible assets, we used the wholesale price index of electrical machinery (Bank of Japan), the composite price index for construction works (Ministry of Construction), and the implicit deflator of GNP (Economic Planning Agency).

The price of capital service is computed from these data for each of the five categories of assets by using equation (2) of section II. For the rate of return, b_t, we used the rate of return to the bonds guaranteed by the Japanese Government (reported by the Bank of Japan). The tax rate T_t is estimated from NTT's annual reports; it is the actual tax paid by NTT divided by the book value of NTT's assets composed of land, buildings, machinery and vessels, and construction in progress. We applied the tax rate to buildings, other equipment and land only. Also, we neglect corporate income taxes paid by NTT after the 1985 privatization.

(2.3) Cost of Capital Input

The total cost of the capital input is computed by multiplying the user cost of capital stock and summing it over all types of capital assets. The cost share of each capital assets are used to compute the user cost of aggregate capital using Törnqvist-Theil index procedure in equation (7) of section II. The aggregate quantity index for capital input was computed by dividing the total capital cost by aggregate capital service price.

(3) Price, Quantity and Cost of Other Inputs

(3.1) Labor Input

The time-series data on hours worked and total compensation paid by each type of employees are necessary to compute the labor quantity and price indices appropriately. In the absence of the ideal data, we simply used number of employees as the labor quantity. The price index for labor input was computed by dividing the total labor payment by the average number of employees.

(3.2) Materials Input

To obtain the index for materials input, we used the sum of materials expenses and purchased services reported in NTT's annual reports. This sum was divided by the implicit deflator for GNP to generate the quantity index for materials input.

(4) Aggregate Input

The aggregate input quantity index was computed by applying the Törnqvist-Theil index number procedure to the three inputs: capital, labor, and materials. The aggregate input price index was computed by dividing the total factor cost by the output quantity index.

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Table I: Total Factor Productivity (TFP),
Output Index (Q), and Input Index (Z):
Level and Rate of Change (with ')

	TFP	Q	Z	TFP'	Q'	Z'
1971	1.00	1.00	1.00			
1972	1.03	1.16	1.12	3.27%	15.68%	12.02%
1973	1.09	1.33	1.22	6.01%	15.32%	8.78%
1974	1.14	1.47	1.28	4.50%	9.82%	5.09%
1975	1.23	1.68	1.37	7.37%	14.46%	6.61%
1976	1.05	1.51	1.44	-14.34%	-9.82%	5.27%
1977	1.21	1.82	1.51	14.66%	20.48%	5.08%
1978	1.19	1.90	1.59	-1.24%	4.21%	5.52%
1979	1.20	2.00	1.67	0.31%	5.21%	4.88%
1980	1.20	2.08	1.74	0.00%	3.90%	3.89%
1981	1.20	2.14	1.78	0.49%	3.23%	2.72%
1982	1.22	2.24	1.83	1.74%	4.43%	2.65%
1983	1.26	2.36	1.87	3.19%	5.47%	2.21%
1984	1.32	2.53	1.91	4.81%	7.12%	2.21%
1985	1.39	2.64	1.90	5.06%	4.29%	-0.73%
1986	1.42	2.73	1.92	2.48%	3.64%	1.13%
1987	1.49	2.89	1.94	4.83%	5.69%	0.82%

		TFP'	Q'	Z'
AVERAGE:	1971-87	2.53%	6.85%	4.22%
	1971-77	3.18%	10.52%	7.11%
	1971-83	1.95%	7.42%	5.36%
	1977-83	0.74%	4.41%	3.64%
	1983-87	4.29%	5.18%	0.85%

Table 2: Total and Partial Factor Productivities:
Level and Rate of Change (with ')

	TFP	LFP	MFP	KFP	LFP'	MFP'	KFP'
1971	1.00	1.00	1.00	1.00			
1972	1.03	1.12	1.09	0.96	11.87%	8.52%	-3.76%
1973	1.09	1.26	1.31	0.90	12.74%	21.16%	-6.50%
1974	1.14	1.35	1.48	0.82	7.25%	12.88%	-8.68%
1975	1.23	1.51	1.58	0.83	11.95%	6.65%	1.17%
1976	1.05	1.34	1.43	0.68	-11.27%	-9.96%	-18.36%
1977	1.21	1.60	1.62	0.76	19.22%	13.42%	11.91%
1978	1.19	1.65	1.62	0.72	3.31%	0.49%	-4.84%
1979	1.20	1.74	1.63	0.70	5.09%	0.05%	-3.41%
1980	1.20	1.82	1.57	0.68	4.38%	-3.36%	-2.43%
1981	1.20	1.88	1.58	0.67	3.39%	0.68%	-1.48%
1982	1.22	1.98	1.62	0.67	5.51%	2.32%	-0.37%
1983	1.26	2.13	1.64	0.68	7.41%	1.55%	1.31%
1984	1.32	2.30	1.67	0.70	8.32%	1.56%	3.78%
1985	1.39	2.48	1.88	0.71	7.74%	12.77%	1.12%
1986	1.42	2.63	1.81	0.73	5.85%	-3.68%	2.33%
1987	1.49	2.84	1.81	0.76	8.03%	-0.22%	4.54%
		AVERAGE:		1971-87	6.74%	3.77%	-1.70%
				1971-77	8.17%	8.33%	-4.48%
				1971-83	6.49%	4.22%	-3.19%
				1977-83	4.84%	0.27%	-1.89%
				1983-87	7.48%	2.43%	2.93%

Table 3: Index of Revenue (R), Aggregate Output (Q), and Output Price (P): Level and Rate of Change (with ')

	R	Q	P	R'	Q'	P'
1971	1.00	1.00	1.00			
1972	1.17	1.16	1.01	17.40%	15.68%	1.48%
1973	1.37	1.33	1.03	16.71%	15.32%	1.20%
1974	1.52	1.47	1.04	10.70%	9.82%	0.81%
1975	1.73	1.68	1.03	14.30%	14.46%	-0.15%
1976	2.07	1.51	1.37	19.48%	-9.82%	32.49%
1977	2.82	1.82	1.55	36.25%	20.48%	13.09%
1978	3.00	1.90	1.58	6.27%	4.21%	1.97%
1979	3.17	2.00	1.59	5.60%	5.21%	0.37%
1980	3.31	2.08	1.59	4.39%	3.90%	0.48%
1981	3.42	2.14	1.60	3.56%	3.23%	0.32%
1982	3.58	2.24	1.60	4.51%	4.44%	0.07%
1983	3.74	2.36	1.59	4.56%	5.47%	-0.87%
1984	3.87	2.53	1.53	3.31%	7.12%	-3.56%
1985	4.04	2.64	1.53	4.52%	4.29%	0.22%
1986	4.19	2.73	1.53	3.79%	3.64%	0.15%
1987	4.37	2.89	1.51	4.23%	5.69%	-1.38%
AVERAGE:			1971-87	9.66%	6.85%	2.62%
			1971-77	18.88%	10.52%	7.56%
			1971-83	11.62%	7.42%	3.91%
			1977-83	4.81%	4.41%	0.39%
			1983-87	3.96%	5.18%	-1.16%

Table 4: Index of Cost (C), Aggregate Input (Z), and Input Price (W): Level and Rate of Change (with $^{\cdot}$)

	C	Z	W	$C^{\cdot}$	$Z^{\cdot}$	$W^{\cdot}$
1971	1.00	1.00	1.00			
1972	1.18	1.12	1.05	18.10%	12.02%	5.43%
1973	1.05	1.22	0.86	-11.29%	8.78%	-18.45%
1974	1.04	1.28	0.82	-0.34%	5.09%	-5.16%
1975	1.78	1.37	1.30	70.52%	6.61%	59.94%
1976	2.15	1.44	1.50	20.83%	5.27%	14.78%
1977	2.32	1.51	1.54	8.00%	5.08%	2.79%
1978	2.75	1.59	1.73	18.49%	5.52%	12.29%
1979	2.24	1.67	1.34	-18.48%	4.88%	-22.28%
1980	2.61	1.74	1.50	16.27%	3.89%	11.92%
1981	3.83	1.78	2.15	46.78%	2.72%	42.88%
1982	3.69	1.83	2.01	-3.72%	2.65%	-6.21%
1983	3.82	1.87	2.04	3.62%	2.21%	1.37%
1984	3.95	1.91	2.07	3.38%	2.21%	1.15%
1985	4.22	1.90	2.22	6.91%	-0.73%	7.70%
1986	4.80	1.92	2.50	13.56%	1.13%	12.29%
1987	4.70	1.94	2.42	-2.10%	0.82%	-2.89%
AVERAGE:			1971-87	10.15%	4.22%	5.69%
			1971-77	15.09%	7.11%	7.44%
			1971-83	11.82%	5.36%	6.13%
			1977-83	8.64%	3.64%	4.83%
			1983-87	5.29%	0.85%	4.40%

Table 5: Index of Aggregate and Individual Inputs:
Level and Rate of Change (with ')

	Z	L	M	K	L'	M'	K'
1971	1.00	1.00	1.00	1.00			
1972	1.12	1.03	1.07	1.20	3.41%	6.60%	20.20%
1973	1.22	1.06	1.01	1.48	2.29%	-4.81%	23.35%
1974	1.28	1.08	0.99	1.78	2.40%	-2.71%	20.25%
1975	1.37	1.11	1.06	2.02	2.25%	7.32%	13.14%
1976	1.44	1.13	1.06	2.23	1.64%	0.15%	10.47%
1977	1.51	1.14	1.13	2.40	1.06%	6.23%	7.65%
1978	1.59	1.15	1.17	2.63	0.87%	3.70%	9.51%
1979	1.67	1.15	1.23	2.86	0.11%	5.16%	8.92%
1980	1.74	1.14	1.32	3.05	-0.47%	7.51%	6.48%
1981	1.78	1.14	1.36	3.19	-0.16%	2.54%	4.78%
1982	1.83	1.13	1.38	3.35	-1.02%	2.07%	4.82%
1983	1.87	1.11	1.44	3.48	-1.80%	3.86%	4.11%
1984	1.91	1.10	1.52	3.60	-1.11%	5.47%	3.23%
1985	1.90	1.06	1.40	3.71	-3.20%	-7.52%	3.13%
1986	1.92	1.04	1.51	3.76	-2.09%	7.60%	1.28%
1987	1.94	1.02	1.60	3.80	-2.17%	5.93%	1.10%
		AVERAGE:		1971-87	0.11%	2.97%	8.70%
				1971-77	2.17%	2.02%	15.70%
				1971-83	0.87%	3.06%	10.96%
				1977-83	-0.41%	4.12%	6.42%
				1983-87	-2.14%	2.68%	2.18%

Table 6 : Sources of Output Growths:
Growth Rate of Output (Q) and TFP;
Decomposition of Q'

	Q'	TFP'	TFP'/Q'	SlL'/Q'	SmM'/Q'	SkK'/Q'
1971						
1972	15.68%	3.29%	20.96%	6.46%	8.75%	63.84%
1973	15.32%	7.69%	50.15%	6.00%	-8.09%	51.93%
1974	9.82%	6.11%	62.25%	13.25%	-8.25%	32.75%
1975	14.46%	6.54%	45.22%	5.79%	10.10%	38.89%
1976	-9.82%	-15.45%	157.33%	-5.66%	-0.27%	-51.39%
1977	20.48%	15.40%	75.19%	1.81%	5.61%	17.39%
1978	4.21%	-1.56%	-37.11%	6.61%	14.81%	115.69%
1979	5.21%	0.76%	14.67%	0.88%	22.07%	62.38%
1980	3.90%	-0.17%	-4.35%	-4.56%	41.60%	67.31%
1981	3.23%	0.16%	4.91%	-1.33%	12.13%	84.29%
1982	4.43%	1.85%	41.78%	-7.00%	7.76%	57.46%
1983	5.47%	3.24%	59.28%	-10.24%	11.83%	39.13%
1984	7.12%	4.90%	68.72%	-4.98%	13.35%	22.91%
1985	4.29%	4.83%	112.71%	-24.16%	-26.78%	38.24%
1986	3.64%	2.43%	66.89%	-17.13%	30.68%	19.57%
1987	5.69%	4.82%	84.68%	-11.72%	16.80%	10.24%
AVERAGE: 1972-87			51.45%	-2.88%	9.51%	41.91%
1972-77			68.52%	4.61%	1.31%	25.57%
1972-83			40.86%	1.00%	9.84%	48.31%
1977-83			22.05%	-1.98%	16.54%	63.38%
1983-87			78.46%	-13.65%	9.18%	26.02%

Integrated Broadband Networks:
The Role of the Cable Companies

by

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Integrated Broadband Networks: The Role of the Cable Companies

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1. Introduction

The emergence of fiber optics as a cost effective broadband transmission medium for the subscriber loop has led both the telephone and cable television companies to explore available options for integrating this technology into their own communications networks. To the telephone companies, fiber in the subscriber loop could open new broadband service markets while simultaneously enhancing narrowband services. To the cable companies, fiber in the subscriber loop could increase the quality and diversity of broadband network services while preempting rival broadband service suppliers. For both, the perceived stakes are high; the first firm to install fiber to the home may have the jump over competitors in providing the diverse array of information age services predicted by many to be demanded by residential subscribers in the near future.

In this paper, we focus primarily upon the cable industry viewpoint with regard to the technical, economic, and policy issues raised by the deployment of fiber in the subscriber loop. At the outset we emphasize this separation is more out of convenience for this proceeding than a logical distinction based upon the issues at hand; it comes as no surprise that much of what affects the cable companies in this regard likewise impacts the telephone companies and *vice versa*. Our research shows that in order to install fiber in their networks the cable companies must confront the same economic barriers as face the telephone companies, although to varying degrees.

If the installation of fiber increases the array of broadband services available over a cable system, and at lower costs than those facing its competitors, then the cable industry will possess an initial strategic advantage in capturing the economic benefits derivable from the use of fiber optics in the subscriber loop. Thus, one could consider cable company investment in fiber as a preemptive response to proposals for fiber-based networks provided by the local telephone monopolies. Based upon the analysis reported here, we conclude that the prospects for fiber technology ushering in a new round of broadband services to the home in the next decade to be somewhat exaggerated -- the costs of switched video services appear likely to remain too high to justify widespread deployment. Instead, we foresee the cable industry installing fiber to capture limited *operational* benefits without significantly expanding their offered set of broadband services. Only in reaction to perceived threats to their monopoly status might the cable industry move to install networks capable of delivering a significantly changed constellation of broadband services. The remainder of the paper is devoted to developing the reasoning behind these statements.

Our approach is divided into three sections: the first discusses some of the technical options open to the cable companies; the second presents an engineering cost model which serves as an analysis tool to examine the economics of alternative fiber installation strategies on the part of cable companies; the third builds upon the discussion of the previous two sections and identifies the fundamental economic and technology trends which are likely to shape the evolution of the current networks.[1]

2. Cable Networks using Fiber Backbones

The cable television industry exists to provide entertainment video services. One-way distributive video services–including both basic and premium channels–are the major revenue sources for the industry. In addition, many cable operators are now installing addressable converters to upgrade their networks to provide a distributive video *pay-per-view* (PPV) service that employs the telephone system for upstream requests. However, even PPV does not provide the subscriber with access to the large number of video alternatives that are available by renting video cassettes for home viewing on a VCR. *On-Demand Video* (ODV) is a network based video library service in which individual requests are transmitted to the subscriber, providing the functional equivalent of video tape rental and a VCR. Just as the telephone network requires a dedicated channel for each subscriber and switching capability to allow voice users access to any information source, so too would the cable system need video switching capability to provide ODV. Digitization and fiber optic technology could provide the means to overcome the past economic limitations of analog switching and the channel limitations of the tree-and-branch design of the coaxial cable system to implement an ODV system.

The most commonly discussed approach to install fiber into the cable television networks is referred to as the *fiber backbone* strategy. The basic idea is to replace the primary trunk lines of a current coaxial cable system with fiber backbones that extend to within a few hundred feet of the subscriber--the remaining distance to be connected using the existing coaxial cable. Deployment of the fiber backbones reduces the number of cascaded trunk amplifiers between the headend and subscriber. In addition, fewer amplifiers in cascade improves network reliability and picture quality, increases system capacity, and provides greater network flexibility for offering a range of new broadband services.[2]

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[1] Sections 1 and 2 have been adapted from Reed, D., Sirbu, M., "A Cost Analysis of a Fiber Upgrade for a Coaxial Cable Network to Support On-Demand Video," *Proceedings of Fiber Networking and Telecommunications Program*, SPIE Boston Symposium OE/Fibers'89, Volume 1179.

A number of potential network architectures employing fiber backbones have been proposed.[3] This paper reports on two fiber backbone alternatives: a mixed digital/analog subcarrier multiplexing (SCM) system and a fully digital pulse code modulation, time division multiplexed (PCM/TDM) system. Although more alternatives exist, we believe these two are representative of a wide spectrum of possible approaches.

This study looks at fiber backbone architectures which go beyond simple improvements to existing services to provide the switched video capability in the downstream direction necessary for ODV. The engineering cost models assume the broadband services that are available after a network upgrade include all the traditional cable television services (including PPV) in addition to ODV. Analysis of such architectures allows us to make a more direct comparison with the fiber-based, switched video networks proposed by the telephone carriers.[4,5] ODV capability may also be necessary to meet the strategic objective of pre-empting the telephone companies from deploying a switched fiber network. For these reasons, we restrict our attention upon switched video alternatives, though we note a majority of the current fiber proposals are generally without switching capability. The non-switched approaches could improve network performance and reliability, in addition to providing the increased capacity requirements that will be necessary to deliver high definition television (HDTV) signals when the time arrives to provide such a service.

The trend in broadband switching is to digital technology. Analog video switching components with stereo sound are available, but expensive, with a cost in excess of $4500/channel. Improved analog VLSI components and increased production could in theory make analog switching more economically viable in the medium term, although no such efforts have been documented. However, several digital crosspoint prototype switching matrices have been demonstrated at broadband signal rates using relatively inexpensive digital VLSI technology. Thus, the model calls for digital switches at the headend. The two architectures under study assume the NTSC video signal arrives at the headend in a compressed, digital format at the STS-1 rate of 51.84 Mbps ready for transmission. The telephone industry has standardized the SONET family of synchronous transport signals (STS) beginning at the STS-1 rate and extending to the STS-48 rate of 2.488 Gbps. Their use by the telephone industry makes it likely that inexpensive optical network components designed to operate at these rates will be available in the medium term.

---

[2] Frequent loss of television signal continues to be the most frequent consumer complaint regarding their cable television service. If one amplifier in a trunk line fails, then all subsequent network branches downstream of the faulty amplifier lose their signal, resulting in a loss of signal over a large area. It is not uncommon for today's cable systems to have 30 - 40 amplifiers in cascade; fiber backbones would reduce this number to 2 - 5 amplifiers in cascade. As a result, network maintenance and operations should be greatly simplified with improved network reliability.

[3] Chiddix, R, Pangrac, D., "Fiber Backbone: A Proposal for an Evolutionary CATV Network Architecture," *NCTA '88 Technical Papers*, National Cable Television Association, Washington, DC, 1988.

[4] Sirbu, M, Reed, D., Ferrante, F., "An Engineering and Policy Analysis of Fiber Introduction into the Residential Subscriber Loop," to appear in upcoming *Journal of Lightwave Technology*, November, 1989.

[5] Reed, D., Sirbu, M. "An Optimal Investment Strategy Model for Fiber to the Home," to appear in upcoming *Journal of Lightwave Technology*, November, 1989.

Figure 2-1 shows the SCM architecture from the headend down to the interface node between the fiber and coaxial cable. The distributive video and on-demand video (ODV) signals arrive at the headend at the compressed STS-1 rate. Since only the ODV signals need to be switched, these channels are fed to a switching matrix. A total of 54 signals are modulated over the spectrum between 1.7 to 7 GHz assuming 100 MHz spacing and combined using a subcarrier multiplexing scheme.[6,7] The interface node connecting the fiber backbone to the coaxial cable distribution plant is denoted as the optical network interface (ONI). At the ONI, microwave receivers simultaneously provide reception for each channel, after which the signals are frequency shifted to the appropriate channel and fed to an amplifier for transmission over coaxial cable.

Because the system assumes two-way communication, two-way amplifiers are installed over the final segment of coaxial cable as part of the upgrade procedure. A microprocessor at the ONI polls the addressable converter on the subscriber premises and directs the video requests upstream to the headend when a channel request is indicated by a subscriber.

The second architecture under study is a digital PCM/TDM system (Figure 2-2). Again the video signals arrive at the headend at the STS-1 rate. The distributed video channels are combined with the ODV channels using a SONET multiplexer. Line speeds for the fiber backbone at the STS-12 rate (622 Mbps) and the STS-48 rate are considered. With a backbone speed of STS-12 corresponding to 12 video channels per fiber, each channel serves one subscriber connection and the network architecture is essentially a dedicated double star. At the ONI, a SONET demultiplexer separates the channels, which are then decompressed, converted to analog NTSC format, and modulated for

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[6] Tang, D.,"Multi-gigabit Capacity Fiber-optic Video Distribution System Using BPSK Microwave Subcarriers", *Optical Fiber Communication Conference Technical Digest*, Houston, 1989.

[7] Way, W., Zah, C., Menocal, S., Cheung, N., Lee, T.,"Carrier-to-noise Ratio Performance of a Ninety-channel FM Video Optical System Employing Subcarrier Multiplexing...," *Optical Fiber Communication Conference Technical Digest*, Houston, 1989.

transmission over the coaxial cable. Upstream communication is handled in the same manner as the previous architecture.

3. Engineering Cost Models

We have developed an engineering cost model to calculate the incremental costs of upgrading an existing coaxial cable network using fiber trunks under various assumptions regarding component costs and user demand. The model determines the network costs from the headend to the subscriber, including the cost of a video jukebox co-located in the headend to provide on-demand video. The network architectures under consideration assume near to medium term (3-5 years future) technology options. Present component costs can be expected to decline as technology matures, as commonly used circuits are implemented as single VLSI chips and as widespread deployment pushes manufacturers down the learning curve. Forecast component costs reflect this assumption.

3.1 Fiber Backbones Deployment Issues

The number of subscribers who can be served by a single fiber backbone depends upon the geographical layout of the existing cable system, the characteristics of demand and the mix of broadband services to be carried over the fiber.

3.1.1 Geographical Layout of the Cable System

The model assumes a cable system serving a square area, 160 homes on a side, containing 25,600 households. Homes are uniformly distributed throughout a square grid of streets and rights-of-way, which determines the trunk and feeder routes. Because of the square layout, most of the feeders branch off to serve roughly 32 subscribers. Thus, the geographical layout of the system is partial to backbone subscriber capacities of 32 per fiber, or convenient multiples of this value. To reduce the number of possibilities to be modeled, and except for a single case of a backbone serving only 12 subscribers, the model only considers backbone subscriber capacities of integer multiples of 32.

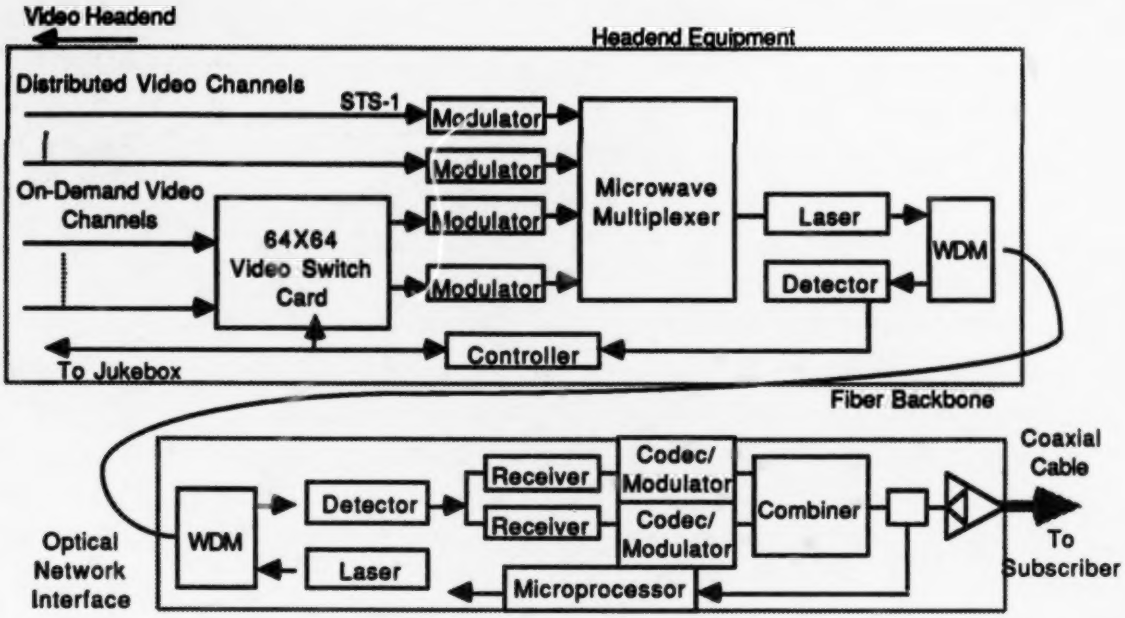
Video Headend
Headend Equipment
Distributed Video Channels
STS-1
Modulator
Modulator
Modulator
Modulator
On-Demand Video Channels
64X64 Video Switch Card
Microwave Multiplexer
Laser
WDM
Detector
Controller
To Jukebox
Fiber Backbone
Coaxial Cable
Codec/ Modulator
Codec/ Modulator
Receiver
Receiver
Detector
Combiner
WDM
Laser
Microprocessor
Optical Network Interface
To Subscriber

Figure 2-1: Fiber Backbone using SCM

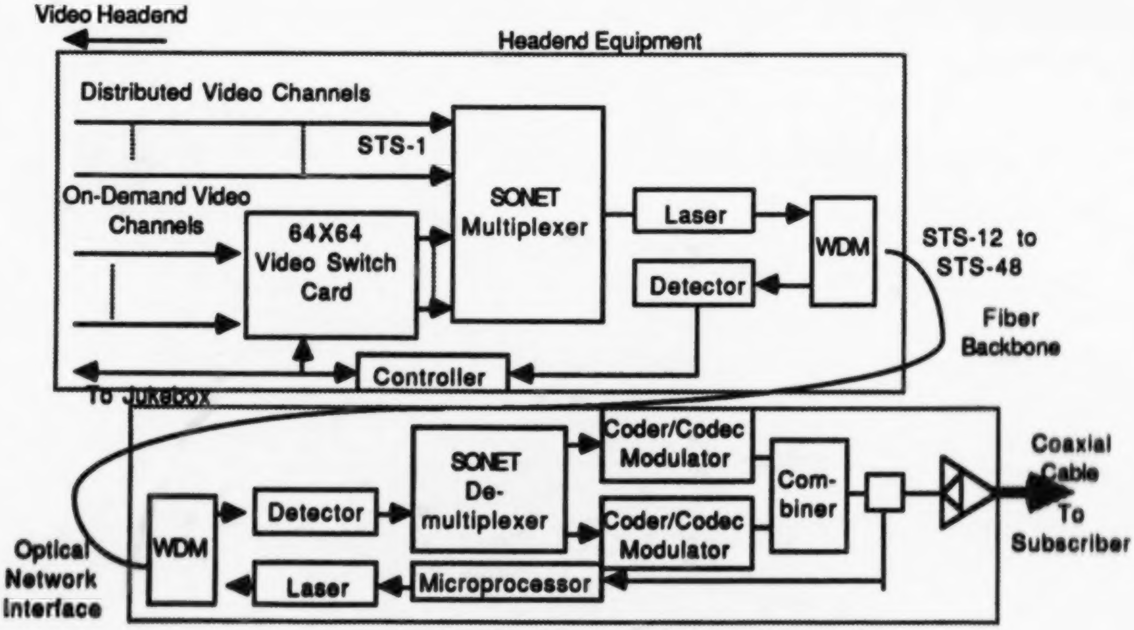
Video Headend
Headend Equipment
Distributed Video Channels
STS-1
On-Demand Video Channels
64X64 Video Switch Card
SONET Multiplexer
Laser
WDM
Detector
STS-12 to STS-48
Fiber Backbone
Controller
To Jukebox
SONET De-multiplexer
Coder/Codec Modulator
Coder/Codec Modulator
Com-biner
Coaxial Cable
To Subscriber
WDM
Detector
Laser
Microprocessor
Optical Network Interface

Figure 2-2: Fiber Backbone using PCM/TDM

3.1.2 The Demand for Broadband Services

The anticipated demand for various broadband services dictates how much capacity should be installed in the network, or more importantly, the number of subscribers that can be served from a single fiber backbone given the technology. In order to dimension the network, estimates of the traffic patterns for broadband services are required, especially those services needing a dedicated video channel to the subscriber such as ODV.

The number of channels required for ODV is estimated using a full availability, loss system modeled by the Erlang B formula, where the probability of no channel being available to service a request–the Grade of Service–is set to 1%.[8] A key parameter, P, is the percentage of subscribers requesting a channel during the peak busy viewing hour. It is defined by the product of the average hourly video traffic per subscriber per week (A) and the percentage of such weekly traffic which occurs during the peak busy hour (p). For example, if the average subscriber views one 90 minute video per week ($A=1.5$) and 10% of the traffic occurs during the peak busy hour ($p=0.1$), then $P=0.15$. Alternatively, we could interpret P as the "ratings share" of ODV, reflecting the percentage of all televisions in the area tuning in to on-demand television during the peak hour. In this view, P would have to saturate well below 68%, the percentage of households typically viewing television on any given evening.[9]

Reflecting the uncertainty in calculating the value of P, we consider a range of values for A between 45 minutes to 6 hours per subscriber per week. However, one would not expect the relationship between P and A to be linear over the entire range of A. An increase in A reflects watching different videos throughout the week, and as a result the overall percentage of video requests in the busy hour, p, would decrease. Thus, over the range of A between 0.75 to 6 hours per week, our model assumes P varies in a piece-wise linear fashion as shown in Figure 3-1. All calculations assume 20% second video drops to subscribers, with the usage on the second drop at 50% of the usage on the primary drop.

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[8] Schwartz, M., Telecommunication Networks: Protocols, Modeling, and Analysis, (Addison-Wesley, Reading, MA, 1987).

[9] Friedman, W., "Rating cable by people meters," *Cablevision*, November 7, 1988, pp. 24-26.

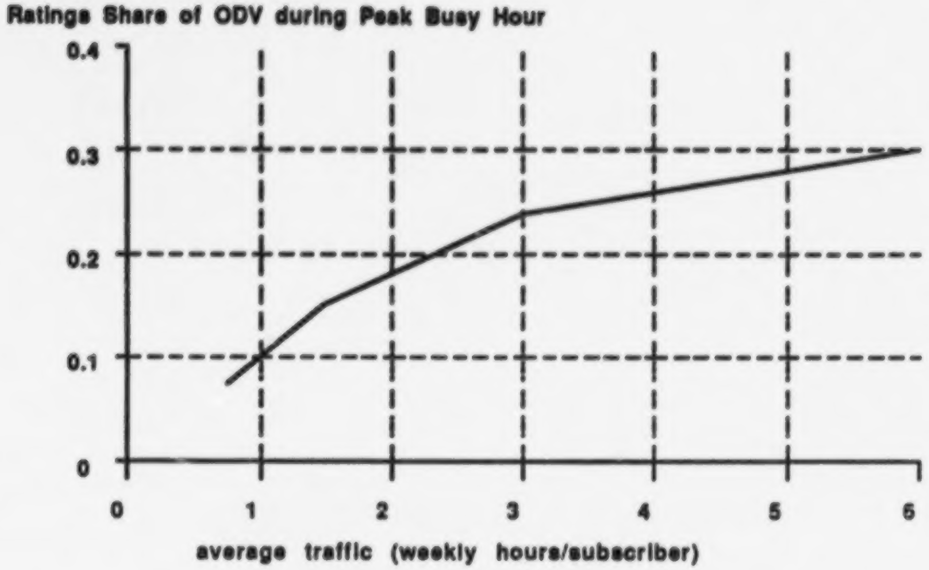

Figure 3-1: Estimated Ratings Share of ODV Viewing

3.1.3 Allocating the Bandwidth to Broadband Services

The available capacity on a cable is split between traditional distributive video channels and ODV channels. A distributed video channel continually delivers a single network feed, while an ODV channel could take advantage of switching functionality to provide either a requested video or another basic programming channel not included among the standard distributed video channels. Thus, ODV channels provide the cable programmer with more flexibility to configure the broadband service mix carried over the system.

When considering current television viewing, the major network affiliates, combined with a few independent stations and national cable channels, account for a great majority of programming tuned to by the subscriber. With this in mind, a backbone carrying relatively few distributed video channels, in the range of 8-12, could usually satisfy the requirements for this type of television viewing. The remaining distributed video channels not pre-allocated any capacity on the fiber could be offered over an ODV channel. ODV access to the less popular cable channels provides a lower quality of service than dedicated channel access, since there is likely to be significant blocking on the ODV channels at the top of the hour when many viewers simultaneously "spin the dial" to scan the available program offerings.

Table 3-1 summarizes the number of subscribers served per fiber backbone for the different architectures as a function of the demand for ODV services. The table also reports the split of channels between dedicated distributed video and ODV in parentheses. As indicated by these figures, the number of subscribers that could be served per backbone is highly sensitive to the anticipated demand for the channels. When the demand for ODV increases, then relatively more channels should be devoted to deliver ODV. It also means that fewer subscribers can be served off a given backbone. In practice, ODV usage can be expected to start small and grow over time. An operator can either configure the network for the maximum expected values of ODV usage, or configure for lower values, and upgrade at a future date, which requires replicating equipment at an ONI site, pulling additional backbone fibers, and reducing the number of households served from a single fiber.

Architecture	Backbone Speed	Number of Subscribers per Backbone (Distributed video/ODV split)			
		Average Requested ODV Traffic per Week per Subscriber			
		0.75 hrs/week	1.5 hrs/week	3 hours/week	6 hours/week
PCM/TDM	STS-12	12	12	12	12
PCM/TDM	STS-48	256 (16/32)	128 (16/32)	96 (12/36)	64 (12/36)
SCM	54 channels	256 (22/32)	256 (22/32)	128 (8/46)	96 (10/44)

Table 3-1: Number of Subscribers Served per Fiber Backbone

3.2 Modeling the Cable System

To serve as a baseline for comparison, an engineering cost model has been constructed to determine the installed first cost of a traditional coaxial cable network for the service area. The comparison is informative because the initial layout of the cable plant will serve as the underlying network design upon which all technical upgrades are based. The layout of the cable system is idealized and not based upon actual cable network data. The network design adheres to a few principles common to the literature on the construction of cable television networks.[10,11,12] When buried cable is necessary, the same trench is used whenever possible to carry trunk, feeder, and distribution cables.

The model calls for cable plant to be installed along 2275 segments, where the length of each segment is equal to 16 times the average household lot size. Of the 2275 segments, 100 are trunk cable, 975 are feeder cable, and 1200 are drop cable. Assuming 100 homes per mile with houses on each side of the street, 345 miles of trunk and feeder cable is necessary, a figure which translates into 71' of shared cable and 80' of dedicated cable per subscriber -- close to one estimate of the industry average of 70' of shared cable and 100' of dedicated cable per subscriber.[13] In calculating costs, the model assumes the current ratio of underground to aerial installation of cable systems of roughly 40% buried ($10.5/meter) to 60% aerial ($6.3/meter).

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[10] See Baldwin, T., McVoy, D., *Cable Communication*, (Prentice-Hall: Englewood Cliffs, N.J., 1983).

[11] Rheinfelder, W., *CATV System Engineering*, (Tab Books, Blue Ridge Summit, PA., 1970).

[12] Webb, G., *The Economics of Cable Television*, (Lexington Books, Lexington, MA., 1983).

[13] *Lightwave*, June, 1989, p. 7.

Assuming aerial drops, the average cost for a one-way distributive cable network to all the homes, including headend and converter costs, calculates to $300 per home passed or $500 per subscriber with a 60% penetration rate. Both figures agree with other published sources.[14]

3.3 Modeling the Installation of Fiber Backbones

The development of the engineering cost models for the two fiber backbone architectures introduced earlier requires consideration of numerous network design and component issues.

3.3.1 Network Design

Fiber backbones are assumed to be installed at one time to service the entire area. Enough fiber is installed to handle 100% penetration in addition to the requests by 20% for second video drops. A protection factor specifies the percentage of dark fiber which is installed to cover either fiber failures or future growth. Only enough electronics are installed to service the base of subscribers and every subscriber receives distributed video as well as ODV services.

Implementation of the fiber backbones resulted in a reduction of the number of amplifiers in cascade down from a maximum of 20 amplifiers to 0 - 3 amplifiers, depending upon model assumptions. The location of the ONI was determined by the operating bandwidth of the fiber backbone. A STS-12 backbone speed serves only 12 subscribers, which places the ONI sufficiently close to eliminate all amplifiers between the ONI and the subscriber. A STS-48 can serve 64 subscribers or more, depending upon the estimated ODV viewing traffic, which puts the ONI 1-2 amplifiers away from the subscriber. The length of the fiber backbone varies depending upon the number of video channels carried over the cable but averages 2575 meters long. A fiber spool length of 550 meters dictates the need for several splices ($20/splice) along the way.

Power is available directly at the ONI locations from the local power utility grid. The model assumes the capital cost of providing power throughout the network to amplifiers and equipment is $10/watt. No provisions are made for emergency back-up power.

3.3.2 Component Costs

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[14] Shooshan & Jackson, "Opening the Broadband Gateway: The Need for Telephone Company Entry into the Video Services Marketplace," Washington, D.C., October, 1987.

In developing the model, a number of assumptions need to be made concerning the type and cost of components. See Sirbu, *et al*, for discussion of fiber component costs.[15]

- Single mode fiber ($.10/meter) is used throughout along with wavelength division multiplexers (WDM - $30) to carry bi-directional communication over the same fiber.
- A light emitting diode (LED - $50) is used to transmit at the STS-12 rate; laser diodes ($500) for transmitting at the STS-48 rate and the analog SCM signal ($2500).[16] PIN photodetectors ($50 - $300) are used throughout all systems
- The base case assumes all new cable installations are buried underground at a cost of $10.50/meter. Fiber backbone proposals often call for "overlashing" the fiber cable to the existing aerial coaxial cable to reduce cable installation costs to as low as $1.65/meter.[13] However, because in most scenarios the number of subscribers served per backbone is above 64 subscribers, and the trenching is often shared over many backbones, calculations reveal the overall totals to be insensitive to this parameter.
- In the PCM/TDM architecture, SONET multiplexors combine and separate video channels at the STS-1 rate (STS-12 multiplexer has a $1000 base cost plus $10/channel, STS-48 multiplexer has a $10,000 base cost plus $10/channel). The SCM scenario requires microwave multiplexors which combine the various subcarrier channels, each at a different microwave frequency, into one signal ($1000 base cost plus $100/channel).
- Both architectures require broadband modulators ($100/channel) at the ONI to modulate the video signal to the appropriate frequency for selection by the converter. While substantially lower than the $800 - $2000 per channel prices paid by cable operators today, the modem does not need the equivalent high performance operating characteristics required of current devices located in the headend. The signal from the modem, after nearly flawless transmission over the fiber backbone, need only travel the short distance from the ONI to the subscriber, not through the 30 cascaded amplifiers facing the modem at the headend. This cost is comparable to the current cost of a modem for short distance CCTV applications.
- The SCM architecture requires microwave modulators ($2000/channel to be shared over 1024 subscribers) and receivers ($100/channel) for operation. The popularity of home satellite antennas for reception of video signals has seen the cost of these components decline significantly over the past decade.

The costs for the electronics are marked up a further 40% to cover installation and testing.

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[15] see *supra*, n. 2.

[16] See Baggett, C., "Cost Factors Relative to the Fiberoptic Backbone System," *NCTA '88 Technical Papers*, National Cable Television Association, Washington, DC, 1988.

3.4 Results

Under the assumptions detailed above the models calculate the average cost per subscriber by dividing the total incremental costs of fiber backbone installation, plus related electronics, by the number of subscribers to the broadband services. "Cost per home passed," a common measure of cable system costs, divides the same incremental costs by the total potential subscriber population.

Often the up-front capital costs required to install a large communications network are very high. As a result the cost per subscriber depends strongly upon the penetration rate of the broadband services. Figure 3-2 shows the average cost per subscriber for the analog SCM architecture versus the fractional penetration as a function of the various estimates of ODV traffic. The cost curves associated with average traffic values of 1.5 and 3 hours/week are similar, and appear one superimposed upon the other in the figure. These results suggest the SCM option can deliver switched video at a cost of $1450 per subscriber (870 per home passed) with current penetration near 60% and the base case average of 1.5 ODV viewing hours/week. Table 3-1 provides a breakdown of the costs by network sub-group and shows that almost three quarters of the cost is attributed to the electronic equipment at the headend and ONI.

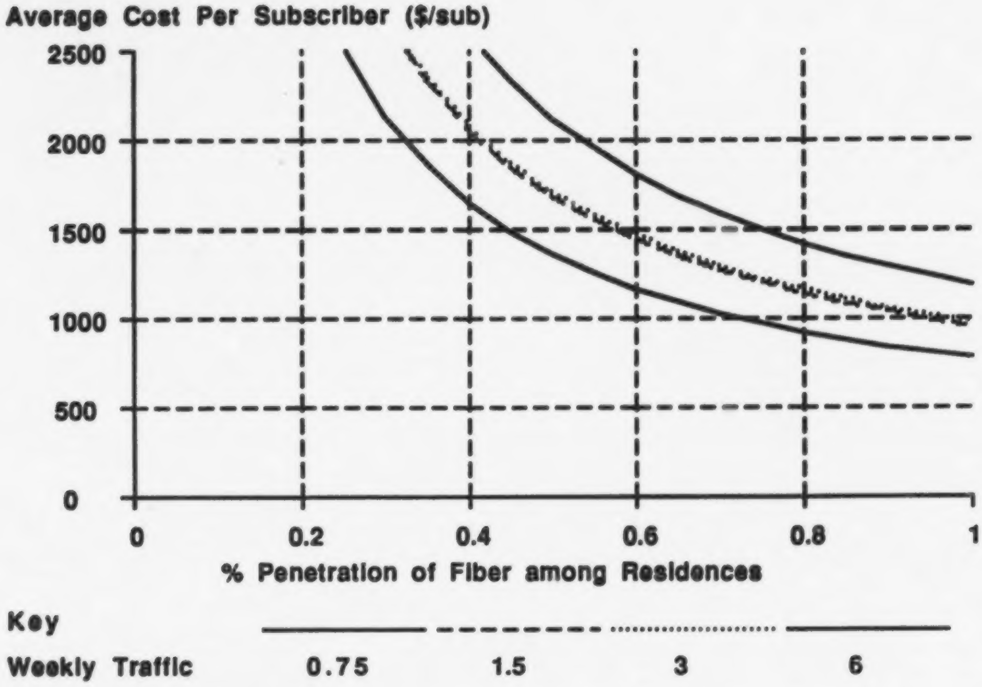

Figure 3-2: Average Cost Per Subscriber for SCM Architecture

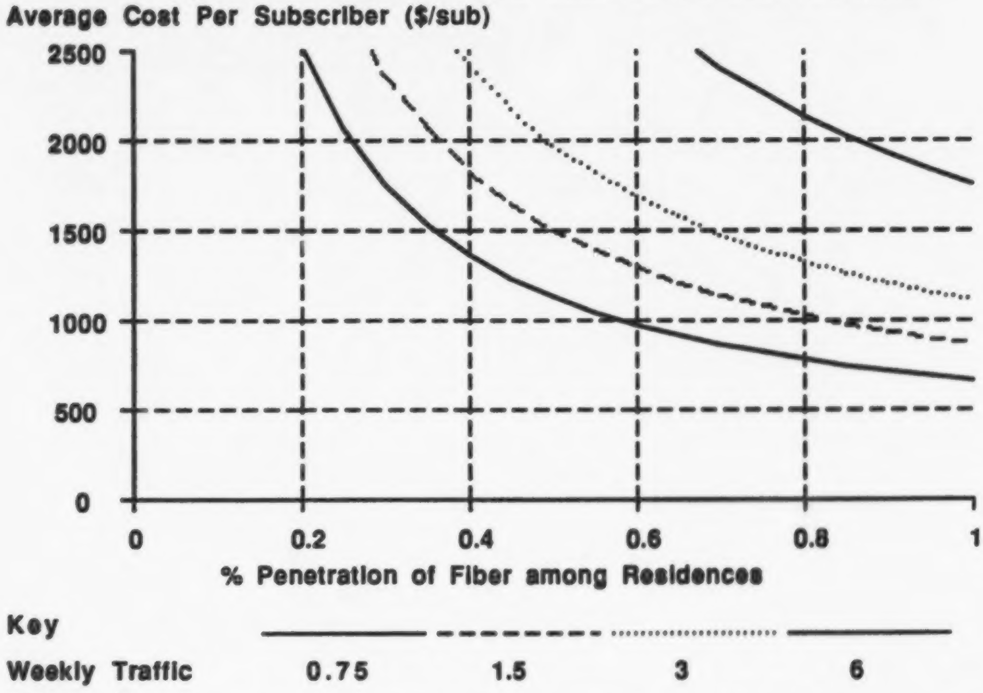

Figure 3-3: Avg. Sub. Cost for PCM/TDM Architecture with Backbone Speed of STS-48

The average cost per subscriber for the PCM/TDM architecture is quite expensive for a backbone rate of STS-12, yet falls off considerably when the rate increases to STS-48. Figure 3-3 illustrates the cost per subscriber for the high bandwidth fiber backbone scenario over the range of ODV traffic estimates. For the base case, the cost per subscriber is approximately $1300 ($775 per home passed). Figure 3-4 shows the case of the fiber backbone operating at the STS-12 rate with the cost of fiber varying between $0.5, $0.10 and $0.20 per meter. Reflecting the need for larger amounts of fiber and associated electronics, the cost per subscriber is $2230 at 60% penetration ($1340 per home passed). The cost curve increases as the penetration nears 100% because second ONIs are being installed to serve the requests for second drops (at 100% penetration, two fiber backbones capable of serving 12 subscribers each are required for each 12 households). Table 3-2 describes the distribution of costs for the base case under the PCM/TDM architecture. The increased electronics costs associated with the STS-48 backbone speeds–given our cost assumptions–are more than offset by savings in the reduced quantity of electronics and plant derived from the larger backbone bandwidth.

In comparing the costs of the two approaches, in the lower range of average traffic value, the high bandwidth PCM/TCM architecture is about $150 per subscriber cheaper at 60% penetration. However, the result of increasing demand for ODV channels tends to reduce this difference until converging to a similar cost at 6 hours per week of average video viewing. As ODV usage increases, channels are shared among fewer subscribers, eventually approaching a dedicated channel per subscriber as in the telephone network. In this limit, the slightly larger number of channels in the SCM architecture allows more households to be served per ONI than with the PCM/TDM approach.

Figure 3-5 illustrates the sensitivity of the cost per subscriber to the estimated electronics cost of the SCM architecture. In this figure, 'High' and 'Low" represent the cases where all the electronics are 150% or 50%, respectively, of their base case costs ('Base Case'). The high bandwidth PCM/TDM scenario exhibits a similar sensitivity to the electronics cost.

Based upon these results, we find no clear preference for either the mixed digital/analog SCM architecture or the PCM/TDM approach. While the model calculations seem to favor the digital PCM/TDM, especially when the demand for ODV is relatively low, given the sensitivity of the results to estimates of the electronic component costs, it is still premature to conclude one approach is superior to the other. Given our cost assumptions, however, it does appear that the STS-48 design is superior to the STS-12 configuration within the PCM/TDM architecture.

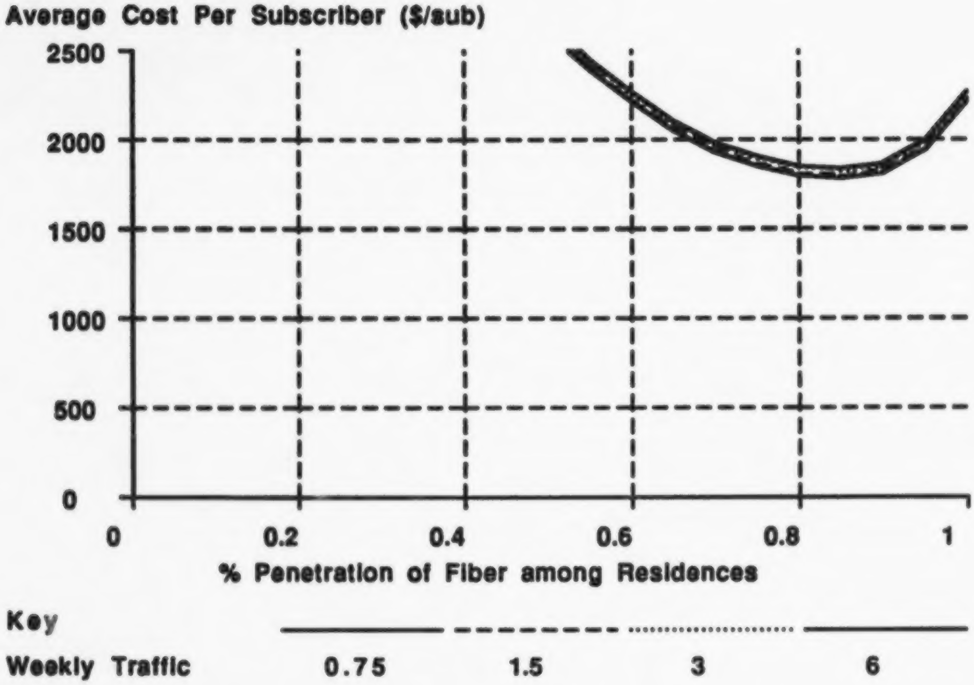

Figure 3-4: Avg. Sub. Cost for PCM/TDM Architecture with Backbone Speed of STS-12

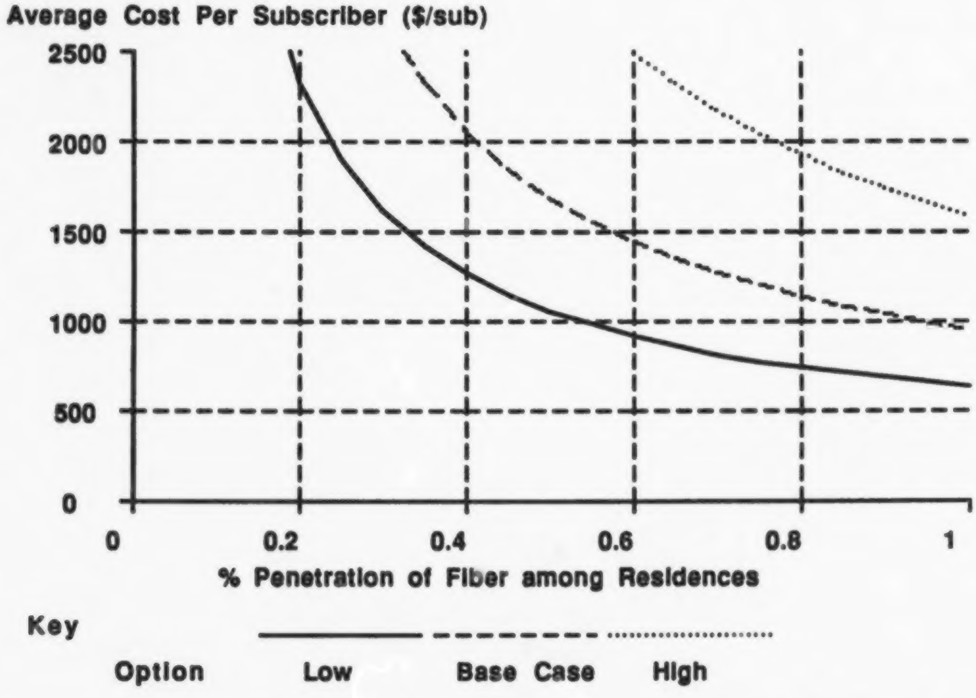

Figure 3-5: SCM Architecture Costs versus Estimated Electronics Costs

Item and Description	Single Item Cost ($)	Average Cost	
		Per Subscriber	Per Home Passed
Headend Equipment			
Video Jukebox	800K+200/channel	91	55
Video Library	25/cassette	19	11
Traditional Cable Headend Equipment		16	10
Video Switching (64X64 Cards)	200/card	61	36
Multiplexer	6.4K	131	79
Microwave Modulator, Coder	2K, 50	246	148
Laser, PIN, WDM	2500, 50, 30	53	32
	Total	617	371
Fiber Backbone			
Fiber, Sheath (per meter)	.10, .05	9	5
Cable Installation	10.5	35	21
Inner Duct (per meter)	0.75-1.15	4	2
Fiber Splicing & Connector	20, 27.5	1	1
Power (per watt)	10	33	20
	Total	82	49
Optical Network Interface			
Multiplexer	6.4K	131	79
LED, PIN RCVR, WDM	50, 5.7K, 30	119	71
Video Coder,Codec,Modulator	40,50,100	210	126
Reinforced Terminal	500	7	4
	Total	467	280
Coaxial Plant Upgrade			
Amplifiers	1000	103	62
Common Plant Sub-Total	Total	1117	683
Subscriber Installation Cost			
Addressable Converter	125	125	75
Hook-up and Installation	50	50	30
	Total	175	105
Overall Total		$1444	$867

Table 3-1: Average Cost per Subscriber for SCM Fiber Backbone

(Hourly viewing = 1.5, Subscriber penetration = 60%)

Item and Description	Item Cost ($)	Avg. Cost (600 Mbps)		Avg. Cost (2.4 Gbps)	
		Per Subscriber	Per Home Passed	Per Subscriber	Per Home Passed
Headend Equipment					
Video Jukebox	800K+.2K/chan	91	55	91	55
Video Library	25/cassette	19	11	19	11
Dist. TV Headend Equipment		16	10	16	10
Video Switching (64X64 Card)	200/card	70	42	62	37
Multiplexer	1.18K-10.72K	239	143	220	132
Transmitter, PIN, WDM	50-500,50,30	26	16	12	7
	Total	461	277	420	252
Fiber Backbone					
SM Fiber, Sheath (per meter)	.10, .05	186	112	8	5
Cable Installation	10.5	141	85	35	21
Inner Duct (per meter)	0.75-1.15	11	6	4	2
Fiber Splicing & Connector	20, 27.5	31	19	1	1
Power (per watt)	10	33	20	33	20
	Total	402	242	81	49
Optical Network Interface					
Multiplexer	1.18K-10.72K	239	143	220	132
LED, Detector, WDM	50,50-100, 30	26	16	4	2
Video Coder,Codec,Modulator	50,40,100	694	416	281	169
Reinforced Terminal	200-500	29	17	7	4
	Total	988	592	512	307
Coaxial Plant Upgrade					
Amplifiers	1000	203	122	103	62
Common Plant Sub-Total		2054	1233	1116	670
Subscriber Installation Cost					
Addressable Converter	125	125	75	125	75
Hook-up and Installation	50	50	30	50	30
	Total	175	105	175	105
Overall Total		$2229	$1338	$1291	$775

Table 3-2: Per Subscriber Cost for PCM/TDM Fiber Backbone

(Hourly viewing = 1.5, Subscriber penetration = 60%)

4. Network Evolution of Cable Networks

In the last two sections, we explored many of the technical and economic aspects of fiber deployment in cable networks. In particular, we described an engineering cost model that calculated the costs of a fiber upgrade to a hypothetical coaxial cable system.

Our analysis has emphasized combinations of fiber and switching investments sufficient to provide an on-demand video distribution service. We focus on ODV because the technology which permits ODV is precisely what is required to enable subscribers access to an unlimited number of program providers. On Demand Video has the potential of transforming television from a medium restricted to a few dozen large programmers to a more democratic medium capable of providing access to literally thousands of video publishers. Video switching reduces the justification for permitting the transport provider to discriminate among information providers by eliminating the capacity constraint posed by a limited number of channels. Policy makers with an interest in promoting information diversity have expressed strong interest in the potential of switched video distribution to foster an explosion of creativity by information providers.[17]

In light of the importance of ODV, what do our results say about its economic prospects? Our analysis suggests that ODV is not likely to become an economically attractive investment opportunity anytime in the next decade. Moreover, this assertion applies equally as well to local exchange carriers as to cable operators.[18]

We also note that the cable operators generally have no competitors in their business of wired video distribution, and will continue to lobby vigorously in an effort to keep it that way. To the extent that public authorities may want to stimulate deployment of switched video services in order to realize the public policy goal of information diversity, some stimulus to the market or change in the rules governing competition may be required.

In this section we explore further the basis for our assertions, and consider several scenarios for the evolution of fiber investments by the cable industry, and implications for future integrated broadband networks.

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[17] U.S. National Telecommunications and Information Administration, *Video Program Distribution and Cable Television: Current Policy Issues and Recommendations*, (GPO: Washington, D.C., 1988).

[18] See *supra*, n. 4.

4.1 The Prospects of Switched Broadband Services to the Home

Existing cable television networks are optimized for delivering a common set of distributive video channels to all subscribers. Their tree and branch design permits extensive sharing of cable plant among subscribers. By contrast, local telephone networks are organized as logical stars in order to provide each customer with a dedicated circuit. In order to provide ODV, the cable company must move in the direction of a dedicated channel for each subscriber. The extent to which common plant can be shared over many subscribers decreases in proportion to the increase in ODV usage, with correspondingly higher costs per subscriber. This is the primary reason why provision of a significant level of ODV capability is so expensive.

Moreover, as the demand for ODV service increases, the cable operator must reallocate the limited channels available on the coax drop from distributed video to ODV usage. This in turn creates a derived demand for ODV service to accommodate viewers of those cable channels which lose their dedicated slots. The derived demand requires further investment in ODV support, acting as a multiplier on the incremental capital cost of servicing the original increase in ODV demand. The phenomenon is similar to the effect on telephone switch blocking of rapid redialling.

Conversely, if there is no provision for ODV, a fiber backbone upgrade is relatively inexpensive. In an earlier study, Baggett estimated the cost per subscriber of an upgrade to fiber backbones, with no provision for ODV, to be as low as $36 per subscriber.[13] In that analysis, a single fiber backbone served approximately 345 households with 50 channels, cable installation was set at a relatively low $1.65/meter, and no new amplifiers or converters were installed to the existing plant. Switched video capability reduces the number of households which can be served per fiber, while adding substantially to electronics costs. Thus, our results show, for 1.5 hours/week/subscriber of ODV usage, a minimum cost of more than $550 per home passed for electronics alone, or nearly $930 per subscriber at 60% penetration.

At the same time, these costs are substantially below the roughly $1600 per home passed capital costs of rebuilding the local exchange carrier's (LEC) telephone network with optical fiber to provide the same level of video service—plus voice services—using a double star architecture. Although the $1600 investment provides voice services to the entire service area and video services to 60% of the households, all of the cost should be allocated to the video services unless one assumes that the LEC is prepared to write off billions of dollars in existing copper plant. For new subdivisions, even at $1,000 per subscriber for new copper telephone plant, an LEC integrated broadband network is barely competitive with a new copper telephone network plus a new cable television network providing a similar range of services.

A significant difference between an upgraded CATV network and proposed LEC integrated fiber networks emerges when we consider the impact of future growth in ODV usage. The active double star architecture favored by the LECs allows expansion of ODV service at relatively modest cost: roughly $35 per additional hour of average subscriber viewing. By contrast, the incremental capital cost that would result from an increase of one hour of weekly ODV viewing is $400 per subscriber for the PCM/TDM architecture at the STS-48 rate and $115 per subscriber for the SCM architecture. These base case figures are shown in Figure 4-1, along with the incremental capital costs when the estimated costs of electronics components are halved and doubled (labeled as 'Low' and "High", respectively).

The higher incremental capital costs for the PCM/TDM architecture at the STS-48 rate relative to the SCM architecture stems from the reduced number of subscribers served per fiber backbone at the higher levels of ODV traffic (see Table 2-1). The incremental capital cost for the PCM/TDM architecture at the STS-12 rate is just $10, a figure that reflects only the additional costs required in the headend because this approach pre-installs in one step all the necessary fiber and electronics components. These calculations confirm our earlier observation that the LEC designs trade higher fixed costs for lower variable costs of capacity by pre-installing a dedicated channel per fiber per subscriber. Much of the cable system up-front cost advantage comes from more effective plant sharing—when providing traditional cable TV services—than occurs in the LEC designs.

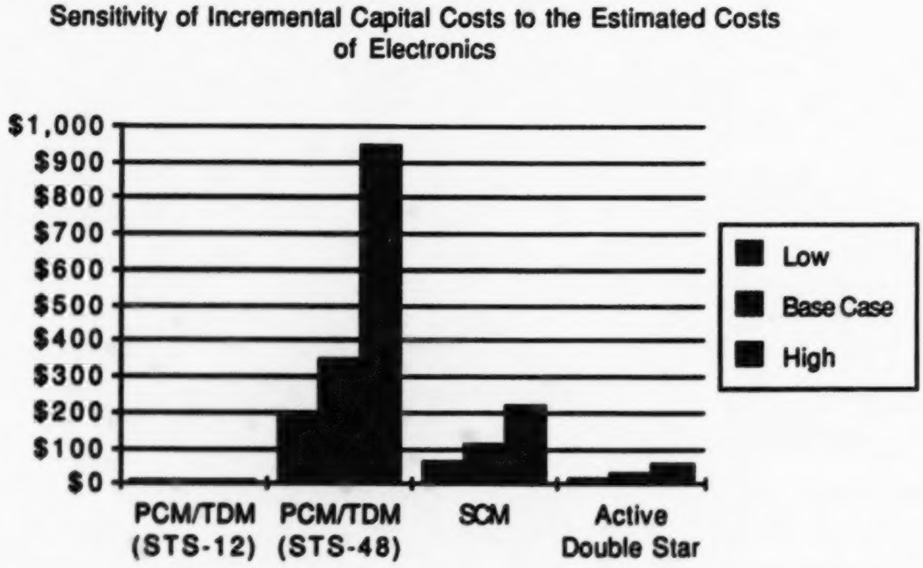

Figure 4-1: Incremental Capital Costs of On-demand Video Viewing

This level of incremental capital costs may have significant demand effects. Each hour per week of increased viewing generates 52 additional revenue generating hours per year to recover the associated incremental capital cost; assuming a cost recovery factor of .33 per year, the incremental capital for our base case cable system represents a charge of $0.75 - $2.60 per hour depending upon architecture. A comparable calculation for the LEC double star architecture finds a charge of $0.25 per hour. Additional revenue will be required to cover video copyright and operations costs. With home videos being routinely rented for as low as $1 per viewing, these charges may present a serious economic barrier to realizing an ODV service over cable networks. Even with a longer depreciation period—more suitable for an earlier monopoly age—these hourly costs remain significant.

While our cost estimates suggest further technological gains will be necessary if switched video services are to be deployed within the next decade, one must still be cautious in interpreting the results. While we do not consider it likely, unforeseen breakthroughs in technology could conceivably alter the cost characteristics of broadband networks – coherent modulation and detection or high density WDM techniques are often mentioned in this context. We note, however, that our analysis does include several aggressive assumptions with regard to component costs and packaging, and still the costs of ODV service appear high.

We note also that the architectures analyzed here all presume the video signal is digitally encoded at the STS-1 rate. It is unlikely that HDTV signals can be economically compressed to the STS-1 rate; thus significant changes in the system would be necessary to accommodate HDTV. Future developments in WDM or coherent transmission techniques could make it economical to accommodate HDTV using the same fiber backbone layout with modified ONI and headend equipment.

4.2 Gradual Evolution of Cable Networks

If the cost of switched video services is prohibitively high, how might the cable companies begin to use fiber over the next decade? In this section we explore some alternative scenarios for the deployment of fiber by cable operators.

It seems clear that the cable operators will not continue to rely forever on traditional copper cable. In the past, observers have argued that the cable industry lacked the technical expertise or R&D capability to invest in emerging technologies such as fiber. These arguments have gradually evaporated as the larger multiple system operators (MSOs) have proposed strategies, like the fiber backbone approach, to introduce fiber into their networks.[19] Further evidence of there growing technical strength is provided by the formation of a new cooperative research organization,

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[19] For example, see Bailey, W., "Fiber Optic Uses in the Cable Industry," *Proceedings of Fiber Networking and Telecommunications Program*, SPIE Boston Symposium OE/Fibers'89, Volume 1179.

Cable Television Laboratories, Inc., to keep abreast of new technology developments with potential applications for the cable networks.[20] Furthermore, vendors and distributors with the necessary technical expertise have emerged which will supply fiber upgrades to the coaxial cable networks, including installation and training of the personnel required to operate the systems.[21]

We expect that the cable operators will, over the next several years, deploy fiber in much the same way as the LECs are deploying it in their subscriber networks. Just as fiber appeared first in intra-office and later in feeder applications, so too will fiber slowly advance toward the subscriber in cable networks. The economics of fiber transmission drive this trend. Further, as the costs of optical communications continue to decrease, the amount of shared fiber will decrease accordingly, moving fiber and the ONI closer to the home, (where the highest degree of dedicated loop plant per subscriber is to be found).

An unfortunate consequence of the grandiose claims surrounding fiber to the home strategies, ranging from "bandwidth on-demand" to "bandwidth transparent networks," is the notion that the fiber medium must necessarily convey a startlingly new array of broadband services to the home. This by no means need be the case. Fiber backbones can be deployed that will replicate the current cable television services, albeit with better service quality, without delivering any new broadband services. Put simply, fiber can make the cable industry that much more efficient at doing what they do best: distributing television signals over terrestrial networks.

Initially, deployment of fiber backbones will be virtually transparent to the subscriber -- perhaps visible only in the improved performance and reliability of the cable system.[22] These strategies are relatively low cost; some estimates are as low as $30 per subscriber.[23] As fiber gets closer to the subscriber, the resultant reduction in amplifier cascade will increase the usable bandwidth of the remaining coax, making more channels available. More premium and more pay-per-view channels will materialize, offering the subscriber more variety in video selections.

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[20] See "Cable Firms Form Venture to Study New Technologies," *Wall Street Journal*, May 9, 1988, p. 24.

[21] AT&T has licensed a distributor to market a fiber optic transmission link with applications for the distribution loop of cable networks. For a description of the system, see Cudworth, S., "Broadband Fiber Optic Transmission Link for CATV Video Conferencing and LAN Trunking," *Proceedings of Fiber Networking and Telecommunications Program*, SPIE Boston Symposium OE/Fibers'89, Volume 1179

[22] See *supra* n. 17. This system would deploy a fiber backbone capable of delivering anywhere between 30 and 50 video channels, depending upon the distance required, over a single fiber using amplitude modulation (AM). The system interfaces easily into the existing network because the ONI fits into a package similar in dimensions to the current amplifier casings and can be attached to a pole in the field. The backbone would not provide switched video services, or even more advanced pay per view services since at this point in time the systems being proposed have no upstream capability.

These developments could have significant implications for the future prospects of switched video services. For example, within the next decade, fiber backbone links could be deployed with enough capacity to provide the basic distributive video channels in addition to several tens of channels that could be used for pay-per-view channels. Often referred to as "near on-demand" video, such a system would enable the cable operator to offer perhaps the 50 most popular movies on a round the clock basis.[24] Given our unfavorable analysis regarding the economics of switched video, one would imagine the outlook for switched services would become even more improbable in the presence of strong pay-per-view alternatives.

4.3 Accelerated Introduction of Fiber

We have painted above a network evolution scenario, notable in its lack of switched video services, for a relatively gradual introduction of fiber by cable operators. What changes in the regulatory or competitive environment might alter our forecast and lead to a substantial acceleration of this leisurely pace?

In light of the recent appearance of several new fiber-based competitive local exchange carriers in various major cities, might the cable companies accelerate fiber deployment with the intention of attacking the same market for business voice and data services envisioned by companies such as New York Teleport, or Eastern Telelogic?[25] We find this a highly unlikely scenario. As became clear when several cable operators were forced during the franchising process to build "institutional" cable systems, business users and residential subscribers are in different parts of a city. There are few opportunities to share common plant for these two uses. Secondly, by their failure to exploit the use of their existing coaxial networks to provide bypass services, the cable operators have demonstrated their lack of interest in these markets. Whether their lassitude is due to lack of marketing expertise, a reluctance to step up to the much more rigorous reliability requirements imposed by voice and data users, or fear of being regulated as common carriers, cable operators have demonstrated little appetite for competing head to head with the LECs for data and voice traffic.

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[23] See supra n. 15. Our model is not easily compared with these figures because of our assumption requiring switched video capability within the system, which places the ONI closer to the subscribers. However, comparable calculations using our model suggests costs as low as $50 per subscriber may be reasonable.

[24] This term should not mislead the reader to conclude that this service possesses some element common to a switched video service. This approach is strictly a pay-per-view, distributed video service.

[25] Desmond, P., "Cable TV Firms Eye Local Telecom Mart," *Network World*, v5, n30, July 25, 1988, p.11.

A more likely scenario would have the cable operator investing in fiber to avoid a competitive threat to its core business of delivering entertainment video. From whence might such a threat come? Today, most cable operators have an effective monopoly on wired video distribution. While recent court decisions limiting exclusive franchises may reduce the legal barriers to entry, formidable economic barriers remain. A would-be competitive entrant faces an entrenched firm with largely sunk costs. Successful entry will require deep pockets, and probably a significantly differentiated service offering. To the extent that the cable operators are integrating backwards into video production they can withhold programming from potential competitors. One strategy for a competitor might be to offer a qualitatively different service offering, such as by providing on-demand video, or advertising "fiber quality" as U.S. Sprint has done in the voice and data markets.

The local exchange carriers have both the financial resources and the technical expertise to propose a competitive, switched video delivery system based on fiber. The LECs have made clear their desires to attack this market, both in regulatory pleadings, and by their investments in overseas cable operations.[26] Leaving aside for the moment the regulatory barriers to LEC entry into video services let us focus on the strategic and economic issues. As we have seen, LEC proposals for fiber to the home are quite costly. Yet, the financial staying power of the LEC makes it possible, if regulators were to permit it, for the LEC to survive a long period of losses in order to wrest the video services market from existing cable operators.[27] If the regulators do not give the LEC the option of buying out the local cable operator, than the cable company may be forced to respond in kind to an investment in fiber to the home by the local LEC.

Our results suggest that cable operators are well positioned to provide switched video services at even lower cost than the LECs for two reasons. First, they are not burdened by the switching requirements of voice and data services which drive up costs by requiring higher amounts of dedicated plant per subscriber. Second, the cable operator has the advantage of an existing broadband network upon which fiber can be incrementally added. The cable operator can deploy fiber in the portions of the network with a high degree shared plant, and postpone fiber installation in the portions with a high degree of dedicated plant per subscriber, as is the case in the drop loop. The LECs have no such luxury if they wish to offer broadband services. Thus, our analysis suggests a cable operator will invest in switched video only if such an expenditure is necessary to save its core business. An attractive strategy for a cable operator may be to design for a low level of ODV usage at high prices with the hope of pre-empting the most profitable portions of this market.

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[26] Ehrlich, P., "US West Gains Cable TV Stake in Hong Kong," *MIS Week*, v10, n31, August 7, 1989, p.9.

[27] Some regulators may take the position of encouraging LEC deployment of fiber to realize projected social benefits of universal broadband communications.

The exact terms of any future cable-telco competition will be set by the regulators, and these remain to be determined.[28] However, the conditions under which the LECs might be allowed to enter the video market will likely impact the technologies and broadband architectures to be deployed in the subscriber loop. How proposed regulations influence the economics and technologies of broadband networks will be the topic of our future research efforts.

5. Acknowledgements

Support for this research was provided in part by Bell of Pennsylvania.

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[28] See in general Pepper, R., "Through the Looking Glass: Integrated Broadband Networks, Regulatory Policy and Institutional Change," *Federal Communications Commission*, OPP Working Paper No. 24, November, 1988.

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MARKET CONCENTRATION IN THE ENTERTAINMENT INDUSTRY

During the 1980s sizable and important changes have occurred in the structure of the television, film, and video entertainment industries. No presentation of this length can treat all the industries which serve to entertainment to Americans. I choose to concentrate on what we have come to call Hollywood and examine the question of the changing nature of the economic power of the major Hollywood studios.

The recent $15 billion dollar Time and Warner consolidation which created an entertainment giant has drawn renewed attention to the power of companies with Hollywood studio connections. But the Hollywood oligopoly has been with us for sixty years, weathering the Great depression and World War II, the introduction of wide screen and color, the coming of television and then cable television, the coming of home video, and a host of other technological, social and economic changes. In each case, pundits predicted these changes would alter (or even dismantle) the industry's basic structure. The eight major Hollywood studios may not be America's biggest companies, but they surely are among the most adaptable, agile and durable.

Today, the Hollywood majors are remarkably little different than in the late 1920s, with two important exceptions. RKO was nearly dismantled by Howard Hughes during the 1950s and through the past decade the Disney Corporation has moved from a specialized operation to a full-fledged studio. But the story of the past twenty years has been one of more vertical integration and more diversification. Many standing on the outside and wanting in complain bitterly. The goal of this paper is to examine the differences in integration and diversification in the 1980s and to speculate on implications and projections of the future.

In surveying current industry structure, first let me say that there are two weak operations, studios which have a poor track record over the past decade, have little diversification or vertical integration, and thus for the moment continue to be candidates for takeover: MGM and United Artists. Kirk Kerkorian took charge of MGM in the late 1960s, and merged it with United Artists in the early 1980s. In a stunning turn of events in 1985, Kerkorian temporarily sold the MGM "half" to Ted Turner who desperately wanted the classic MGM movies to show on his SuperStation. Few were surprised when a year later Turner sold MGM back to Kerkorian. Between the time I write this paper and deliver it, he is scheduled to sell United Artists to Qintex of Australia. But with Kerkorian little seems very settled in the long run. He has become rich selling his studio assets, but I believe in doing so he simply has brought an end to these two companies as influential competitors and both will cease to be major studios in the near future.

One major, Columbia Pictures, is at present an enigma. During the early 1980s Columbia was a division of Coca-Cola. Coke brought a research-oriented, marketing philosophy to a business where instinct and intuition had long proven the business methodology of choice. Coca-Cola tested a new philosophy for making money from movies. It tried to harness the creative energies in Hollywood by having traditional M.B.A.'s formulate strategies for optimizing sales and rentals from "movie software." Despite a series of attempts at cross-promotional advertisements for soft drinks and movies (consider the case of Diet Coke and Steve Martin's Roxanne), Coke never was able to create a blockbuster film, and in 1988 spun off the company into today's Columbia Entertainment.

In contrast five companies represent billion dollar, multinational media conglomerates, and form the heart of the current Hollywood studio system. They include Paramount Communications, Time-Warner, MCA's Universal, News, Inc.'s Twentieth Century Fox, and the Disney corporation. All generate considerable profits from a wide variety of mass media enterprises including theme parks (MCA and Disney), recorded music (MCA and Time-Warner), publishing (Paramount, News, Inc. and Time-Warner), television stations (all four), and television production (all four).

Every few years a couple of bold pretenders (recently, Cannon, DeLaurentis, and New World Entertainment) emerge to challenge the majors, and capture the headlines of the business press on the basis of one or two modest hits (or even the promise of such). But no challenger has survived over the long run. Indeed Cannon is barely still in business, DeLaurentis is in bankruptcy, and New World is out of filmmaking and has become a independent television producer based on the success of Wonder Years.

Looking at the industry through the 1980s, it would seem the common denominator for the five companies that have done the best is wide diversification. Certainly as could be seen during the public negotiations in the Time-Warner-Paramount deal, Hollywood corporate executives stated over and over again that controlling the markets downstream is vital for their long term survival and prosperity. They publicly argue two positions. First vertical integration enables them to take full advantage of reductions in costs of sales and transactions. More important is the issue of market control. A vertically integrated firm need not worry about being shut out of key markets.

Indeed for theatre ownership major studios are even willing to cooperate. So now, despite all the alleged struggle, Paramount and Time-Warner still jointly own a vast theatre circuit which gives them strong positions in Los Angeles, new York City and throughout Canada. This circuit, called Primamerica, itself was the sixth ranking chain in size in North America.

But the deal which rocked the industry came when MCA joined with Cineplex Odeon. This agreement between the flamboyant Garth Drabinsky, founder and driving force of Cineplex Odeon and Lew Wasserman, long considered the most conservative boss in Hollywood, signaled more than anything that the nearly forty year long era of the Paramount decrees was over. Cineplex Odeon owns and operates more than sixteen hundred screens, brags that it is the largest in North America, and provides Universal with direct access to some of the best situated multiplexs in North America. Indeed as I write MCA seems on the verge of taking direct control of the best of the Cineplex Odeon screens in the United States.

From these and other examples the giants of the American film industry came to realize through the 1980s that the "theatrical window," despite all the talk of the impact of cable TV and home video, is still where blockbuster hits are developed. Feature films begin their marketing life in theatres, and then go on to maximize revenue streams in the ancillary markets of pay-cable, home video, foreign distribution, and over-the-air television only if they had done well at the theatrical box-office. The multiplex is where the return on the twenty-million dollar investment for the average theatrical feature is largely determined. A theatrical blockbuster guarantees millions of additional dollars from the home video and pay television arenas. That is why the major Hollywood companies work so hard to craft a hit in the theatres for once they have a proven commodity there, the rest of the way is usually smooth sailing.

That is why they seek control of the vital core of theatres which regularly give off the bulk of the box-office take.

But the continuing importance of theatres has only become obvious in the last few years. Consider that at the beginning of the 1980s a number of serious pundits studied the film industry, and predicted that there probably would no need for movie theatres by 1990. Everybody could (and would) stay home, and view Hollywood's best through the new television technologies. Instead, what has happened is that going-out-to-the movies has remained viable, setting yet another record this past summer. All this happened even as pay-cable and home video grew into billion dollar industries.

Few predicted ten years ago that during the 1980s more new movie theatres would be built, creating more theatrical screens in the United States than anytime in film history. Theatrical release requires more and more theatre screens so Hollywood can take full advantage of the economies of television advertising. Even through the cost of marketing a film can often exceed ten million dollars, as it is spread over more and more theatres, marketing costs per theatre per film remain relatively low. The economies of scale of television advertising of theatrical features provides the foundation of the multiplex.

But from the point of those on the outside, the so-called independent film companies, they argue that big corporations are simply getting bigger, while precious little programming is aimed at minorities, and fewer and fewer opportunities exist for independent creators. So, for example, approximately 9,000 of the best screens are controlled by the circuits now affiliated with a major studio. These 9,000 accounted, in 1987, for nearly seven-eighths of the theatrical box-office take. During the same year, more than a third of the independent films produced by independents in the U.S. received no U. S. theatrical release, and another third marginal, limited release at best. Here the control of all stages of production chokes off the possibility of new entrants who do not have the resources to compete on a global level and in all the possible markets.

In the talk about the Time-Warner-Paramount deals, many spoke of the importance of the foreign markets as well. Indeed since the 1920s the Hollywood majors have held dominion for distribution throughout the world. Everywhere one went one saw a Hollywood film. That power has not changed, only the types of venues to which films are distributed. Today Hollywood still holds hegemony throughout the world. And its trade association, the Motion Picture Association of America, spends a great deal of time making sure that economic network is maintained. Indeed, the movie business is one of the few positive signs on the United States trade accounting sheet.

Year in, year out the majors control markets from Sweden to Australia, from West Germany to nearly all the nations of Africa. Hollywood derives roughly one-third to two-fifth's of its theatrical box-office revenues from overseas. At considerable expense, they maintain offices in more than a dozen cities in North America (and up to fifty overseas), where their representatives are in constant contact with the heads of the dominant theatre chains. The studio's constant production of hit films impels foreign theatre owners (a conservative lot with most of their assets invested in real estate) and now cable TV outlets to consistently rent the safe films of the majors rather than a flyer with an independent.

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One way to focus on the economic power of the Hollywood studios is to see how effective their system of price discrimination has been and continues to be. In the 1930s and 1940s the Hollywood majors through their ownership and control of production, distribution and exhibition set the prices for the movies shown and through careful use of runs, zones and clearances, were able to maximize revenues from box-office take. In other words they worked together to enforce a system of classic price discrimination. A generation ago the process was simple. Features opened with big premieres and publicity. Then they played off from first to second to third-run, so on down the line. The coming of television simply added two runs at the end. A film earned the bulk of its money from play in theatres; television, even with a sale for showing on one of the three major television networks, accounted for less than a tenth of total revenues.

Today feature films still begin their marketing life in theatres. As noted above, the first-run theatre remains the principle "voting booth." If one can fashion a theatrical blockbuster during the crucial first weekend of release, then one should reap added millions from the home video, and pay television arenas. Even as recently as ten years ago, multiplexes supplied more than three-quarters of the revenue for an average Hollywood feature film. Today theatres provide less than half. Movie theatres are doing just fine, but home video is doing far better.

The financial data from the home video market for movies is indeed impressive, even extraordinary. In 1980 the Hollywood majors collected about twenty million dollars from world wide sales of video cassettes. In 1987 the figure was over seven billion dollars. Ten years ago an average film took in nothing extra from home video; today that revenue contribution usually amounts to one-third.

In the mid-1980s outlets renting video tapes popped up everywhere. Grocery stores, drug stores, convenience chains, gas stations, dry cleaners and even in some locales, pizza delivery services, were willing to lease tapes. Consider that in 1987 fully a sixth of all tapes were rented from grocery stores and drug stores alone. Hollywood has sought ways to participate in this rental market by establishing different prices through time. Initially a tape is sold for close to one hundred dollars, with principle buyers being video rental stores. But once that market has been milked, then a special sale is held for about twenty dollars, aimed at individual buyers.[1]

But home video hardly stands alone in Hollywood's ancillary markets. In 1982 HBO seemed to be on the verge of establishing itself as an eighth Hollywood major. But in recent years pay cable revenues in general, and HBO in particular have begun to level off. Too many folks seem to prefer to rent the cassette when they want to see it, not wait until HBO schedules the film. Still HBO continues to dominate the multi-million dollar pay-cable market.

With repeated showings on pay-cable and home video, the next run, theatrical features shown on network television, has fallen to lows unmatched in the twenty-five years since Twentieth Century Fox and NBC introduced "Saturday Night at the Movies," and so most movies on the networks are TV movies. If ever there was proof that the TV movie had replaced this particular run for theatrical features, it came on a Sunday night in February 1984 when CBS first aired Star Wars. CBS was so confident of high ratings that it doubled its prime-time advertising rates. But to nearly everyone's surprise Star Wars was beaten in the ratings by Lace, a steamy made-for-TV movie which cost only three million dollars to make, less than half what CBS had paid to rent Star Wars.

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[1] The latest innovation to assist the majors in collecting more money is called Pay-Per-Transaction or PPT. As currently being explored, PPT would allow a store to lease its movies from the studios rather than buy them outright. Instead of paying a one time fee, the video store would split (usually fifty-fifty) with the studio the income each time the tape is rented. PPT allows the video renting agent to carry more tapes, and thus satisfy often frustrated customers, and keep them coming back.

The next run for a movie is its presentation by an individual television channel delivered either over-the-air or through cable. Today such independent stations represent an increasingly important market. It usually takes a couple of years for important feature films to make their way to independent television (less for box-office failures), but once released, the film is shown over and over again.

Turner Broadcasting Service's SuperStation provides a classic example of the drawing power of films. For this, the most watched of all cable selections in the United States, fully a third of its time is filled with old films. In 1985 Turner purchased MGM, not for its current productions, but for access to its library of old films. Turner so wanted the old films he paid far more than he could afford, and thus had to sell the remainder of MGM company back to Kirk Kerkorian a year later and go into hock to its cable system customers. Through Turner's SuperStation and the substantial addition of over-the-air independent stations that opened for business during the 1980s, Hollywood has increased it revenues while the vast array of the opus of the its sound films play off, day after day. Indeed to make the product "different," Turner has begun to colorize older black & white features and started a separate movie network, TNT.

Whatever additional new television technologies appear in the future, the business of Hollywood will continue to be to seek additional ways to soak up the most possible money from any and all films. It will do this by trying to formulate policies for the maximum revenue exploitation through price discrimination by segmenting potential customers, and then having them pay as much as possible for a viewing, starting with a theatrical showing, then home video, pay-cable, cable television, network television, local television and so on.

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I have argued that through diversification, integration and a textbook example of price discrimination, the Hollywood major studios have long maintained their power. And to this observer little seems on the horizon which might change that grip. To many this economic structure, conduct and performance is not a problem. But Hollywood is an ordinary industry, but one that is highly visible and symbolic well beyond its place in the overall economy. As was noted above, many want in and independents have long and will continue to complain about the lack of entry. They were able to successfully press their case with the Paramount decrees. Is there anything on the horizon which might change this industry? There seem to be three possibilities.

1. For years the coming of each new technology was predicted as the catalyst to finally alter Hollywood's hold on the marketplace. The argument was based on the principle of the

substitution effect. With pay-cable or home video available at relatively cheap fares, why would anyone want to go out to the movies? But if we have learned anything in the 1980s this factor is not as powerful as many forecast. To me little seems on the technological horizon that would make millions abandon going-out-to-the-movies.

The latest candidate is HDTV. Presumably its superior, wide screen video image will finally represent the ultimate substitute. I doubt this. First, the film image is also improving in quality, and will remain vastly superior to even the best HDTV image. More importantly, in the 1980s we learned that image quality does not seem to matter much. If it did, why did the technically superior Beta format for home video fail so badly in market competition with VHS? People -- especially young people -- go out to the movies for reasons that have little to do with the quality of the image.

2. More likely change might be imposed from outside. An exogenous economic shock in the form of a devastating recession certainly would have effects. If the theatre business depends on steady discretionary income, a recession could cause a substantial decrease in theatrical attendance. Moreover with revenues down, Hollywood would be saddled with its debts in sizable investment in theatres.

Or the outside shock could come more slowly, say from demographic changes. Going-out-to-the-movies might be abandoned by the members of the baby boom generation, long the movies most faithful of fans. They might turn exclusively to television, or something else. Many have long predicted this, but the baby boom (and now their children) have remained faithful film fans, indeed the core of the home video generation.

But however these outside effects manifest themselves, one must over estimate how much they would hurt a well diversified Hollywood. During the Great Depression and the sizable recession of 1969 - 1970, theatre revenues went down, but Hollywood used its power so skillfully that new entrants were unable to take advantage of the situation and join the elite powers of the film industry.

3. There might be a political change. Hollywood certainly took full advantage of the "hands off" policy at the Department of Justice of Ronald Reagan. The Bush administration has promised something new. Moreover there seems to be sentiment in the Congress for re-regulation. This has given those who value more entry in the film business an opening to complain about the power of Hollywood. Yet without some flight of fancy -- the retirement of Jack Valenti, some alliance with the NCTA -- all remains on hold. For now the major Hollywood studios are enjoying the fruits of economic power and prosperity not seen since their Golden Age of the 1930s and 1940s.

PROFILES AND TESTING: THE NEW STANDARDS CHALLENGE

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INTRODUCTION

The great promise of information technology for the 1990's is the introduction of worldwide communication networks that will provide information exchange between heterogeneous computer and communication products and systems. An internationally standardized solution to today's difficulties associated with developing integrated multi-vendor networked computer systems is based on the seven-layered Open Systems Interconnection (OSI) Reference Model. Although there are over 200 international OSI standards in place, it is doubtful that a full complement of international OSI protocols will ever be completely defined, since new applications and new telecommunication technology will always require new standards.

There are several interdependent yet separate activities needed for effective global OSI Networks. Such activities include: international standards development; the follow-on "functional standards" or profile agreements that build on these standards; international harmonization of these agreements and processing as International Standardized Profiles (ISPs); vendor implementation of profile agreements based on technology advancement and market readiness; objective conformance testing to ensure that the implementation does what it promises to do, followed by interoperability testing; the user's decision to adopt an OSI strategy for the specific environment; the user's purchase of the implementation; and finally, the proven interoperability of conforming systems.

Consequently, for OSI to be truly realized, OSI products and communicating end-systems must do more than just conform to several OSI standards as written. This is because, overall, OSI standards offer great flexibility and may contain many optional classes, subsets, and parameters. Use of implementations of the standards, without prior agreements in the choices within these options, may lead to sub-optimum performance and increased implementation cost.

An additional factor that is fueling international OSI efforts is the creation of the internal European market, targeted for 1992, requiring that the standards used to provide such compatibility be the same throughout Europe. The worldwide nature of the Information Technology industry and the growing international exchanges of information make it vital that those standards are also the standards of the world market.

Therefore, manufacturers and users, the world over, interested in OSI products have joined together to reach agreements on precisely stated subsets or combinations of OSI standards, together with selected options within each standard, considered necessary to support a given function. These functions include, for instance, a given application such as electronic mail, or a given network environment such as a packet switched data network. Documents that specify agreements reached in regional or topic-oriented groups have been called by various names including Profiles or Functional Standards, Implementation Agreements, or Implementors Specifications. The International Organization for Standardization (ISO) has defined a new document, the International Standardized Profile (ISP), to encompasses this concept.

The conformance testing of systems implementing a specific profile provides, in turn, another measure of assurance that the implementing systems will interwork. In general, conformance testing will determine whether a specific implementation conforms to the relevant OSI protocol standards by testing both the functional capabilities and the dynamic behavior of the implementation.

This paper discusses the work on profile development and testing that builds upon the developed standards of today to provide for the OSI networks of tomorrow.

OSI BASE STANDARDS DEVELOPMENT

The worldwide OSI standardization effort was initiated in 1977-1978 by the International Organization for Standardization (ISO) to amalgamate and standardize previous open-systems engineering and computer design work. The ISO, a voluntary non-governmental organization founded in 1947, comprises the national standards bodies of 73 countries and includes as correspondent members 14 additional countries. These 87 countries represent more than 95% of the world's industrial production. The United States is represented in ISO by the American National Standards Institute (ANSI). The standardization work of ISO covers almost all areas in human commerce; information technology has now assumed a major role in ISO.

The international OSI effort is centered in a joint ISO and IEC (International Electrotechnical Commission) Joint Committee, JTC1, "Information Technology." Since international standards are public documents, the user is assured that any changes made to the standards will be done in an open, predictable way, thereby protecting investment in products and systems. Table 1 lists the JTC1 committees most closely identified with OSI work. Prodigious efforts have resulted in almost 200 OSI international standards (mostly bit-specifying protocols, transfer syntax, and layer-service definitions) distributed among the seven layers. Each of these standards has taken upwards of 4 years to develop and is generally a multi-million dollar project to complete.

In the United States, information-technology-standards work is done in various committees. The two most significant are Accredited Standards Committee X3 (AS X3), "Information Processing Systems," and IEEE Project 802, "Local Area Networks". Because both operate under the open procedures determined by ANSI, each is accredited by ANSI to present standards for balloting as US National Standards. The work of these two groups is easily carried forward to the international level as preliminary material.

TABLE 1

ISO/IEC JTC 1 SUBCOMMITTEES AND WORKING GROUPS WITH PARTICULAR EMPHASIS ON OSI AND OSI-RELATED STANDARDS.

ISO/IEC JTC 1/SC 6: Telecommunications and Information Exchange Between Systems

Working Group 1:	Data Link Layer
Working Group 2:	Network Layer
Working Group 3:	Physical Layer
Working Group 4:	Transport Layer

ISO/IEC JTC 1/SC 18: Text and Office Systems

Working Group 1:	User Requirements and SC 18 Management Support
Working Group 3:	Document Architecture
Working Group 4:	Procedures for Text Interchange
Working Group 5:	Content Architectures
Working Group 8:	Text Description and Processing Languages
Working Group 9:	User-Systems Interfaces and Symbols

ISO/IEC JTC 1/SC 20: Data Cryptographic Techniques

Working Group 1:	Secret Key Algorithms and Applications
Working Group 2:	Public Key Crypto-Systems and Modes of Use
Working Group 3:	Use of Encipherment Techniques in Communication Architectures

ISO/IEC JTC 1/SC 21: Information Retrieval, Transfer and Management for Open Systems Interconnection

Working Group 1:	OSI Architecture
Working Group 3:	Database
Working Group 4:	OSI Systems Management
Working Group 5:	Specific Application Services
Working Group 6:	OSI Session, Presentation and Common Application Services
Working Group 7:	Open Distributed Processing

ISO/IEC JTC 1/SGFS: Special Group on Functional Standards

Working Group:	Taxonomy of International Standardized Profiles

The CCITT (International Telegraph and Telephone Consultative Committee) is also involved in the OSI effort and, in the areas of joint interest, has developed Recommendations for telecommunications, identical in technical content to ISO standards. In the reverse, some ISO OSI standards are based on CCITT Recommendations (e.g., X.25 and X.400). Consequently, certain OSI profiles include CCITT Recommendations as well as ISO standards. Extensive liaison between ISO and CCITT during the past decade reflects the rapid convergence of computer and telecommunication technologies. The US member of the CCITT is the Department of State.

PROFILE BUILDERS

The technical OSI standards are flexible, offering a broad functionality, and consequently many "degrees of freedom". Such degrees consist of options, classes, parameters, subsets, etc. To be fully interoperable, two implementations must implement the same set of options (set out in profiles). Agreements on these options are reached in "Workshops".

Therefore, in addition to standards groups, there are organizations worldwide developing OSI-related functional profiles. These groups fit generally into three categories:

1. open OSI Implementors Workshops;
2. industry-specific consortia and organizations; and
3. government groups.

OSI Workshops:

There are three Regional OSI Workshops at the time of this writing: the NIST Workshop for Implementors of OSI (1983); the European Workshop For Open Systems (EWOS - 1987); and the OSI Asia and Oceania Workshop (AOW - 1988). The three workshops are similar in most respects:

1. Each serves as an open public forum for users and suppliers of OSI products to develop stable OSI Implementation Agreements forged from widespread technical consensus;

2. Each workshop organizes its work around topic-specific Special Interest Groups (SIGs) (called EGs, Expert Groups in EWOS). A compiled list (i.e., at least one workshop has it) of SIGs at present includes: Lower Layers, Upper Layers, Message Handling Systems (X.400), File Transfer, Access and Management (FTAM), Virtual Terminal, Directory Services (X.500), Network Management, Security, Registration Authority, Office Document Architecture (ODA), Transaction Processing, Remote Data Base Access (RDA), and Manufacturing Message Specification (MMS).

   The SIGs are encouraged to coordinate with standards organizations and user groups, and to seek widespread technical consensus on implementation agreements through international discussions and liaison activities. The resultant agreements specify options and parameters of OSI standards that implementors can use as a specification for product development.

3. The final agreements are based on international standards (i.e., ISO International Standards or CCITT Recommendations). This is a very important point, constantly being challenged in some cases because of the "slow" pace of standards development.

The most significant and far reaching agreements based on the NIST Workshop "Implementation Agreements" (updated yearly) are: US Government Open Systems Interconnection Profile (US GOSIP); the COS Profile Selection; the Manufacturing Automation Profile (MAP); and the Technical and Office Protocols (TOP). Each of these is discussed elsewhere in this document.

A major objective of EWOS is to develop profiles and associated test specifications for Open systems (in cooperation with the Conference of European Posts and Telegraphs [CEPT] and the European Telecommunications Standards Institute [ETSI]) to be approved by CEN/CENELEC on behalf of the European Commission (EC). (CEN/CENELEC, really a merger of two groups, is the prestigious European standards organization which does not develop its own standards but relies on international standards together with those from EWOS and ETSI). Starting in 1992 (and even before) reference to approved profiles (ENs or ISPs) will be compulsory for public procurement in Europe. When an EN is approved, contradictory standards must be suppressed in all European countries.

The council members of AOW include Japan, China, Korea, and Australia. The Workshop is intended to have, as its main work, the harmonization of ISPs. Much of the preliminary work will be based on INTAP's profiles. (See the section below on POSI for more information.)

The three regional workshops coordinate their activities through a newly formed Regional Workshop Coordinating Committee, which also provides for harmonized profile results in areas of common interest.

Industry-Specific Groups:

The following five industry groups (sometimes called "User" groups, sometimes called "Feeders") have specific interest in functional profile development, even though not all are in the business of profile development:

1. Manufacturing Automation Protocol (MAP) Users Group
2. Technical and Office Protocols (TOP) Users Group
3. Standards Promotion and Application Group (SPAG)
4. Corporation for Open Systems International (COS)
5. Promoting Conference for OSI (POSI)

Although "MAP" and "TOP" are often found in the literature joined together as one word, i.e., MAP/TOP, each represents an early, independent effort to specify a set of OSI options/services to meet specific application problems. Dating back to 1983, both projects have been done with close ties to the NIST OSI Implementors Workshop. MAP (General Motors), designed for the factory floor, and TOP (Boeing), designed for the technical office, have no required relationship but may interact. In general, the differences between the two specifications occur in layers 1 and 2 and in overlapping selections at layer 7. Both efforts have expanded from U.S. projects to worldwide programs.

SPAG, COS, POSI and other organizations worldwide, support the desire of vendors and users alike to develop "open" solutions which permit them to concentrate on providing functionality to meet customer requirements and ultimately to increases sales and market share. In the world of proliferation of computer based products and services, users have become frustrated with the constraining nature of many systems and seek flexibility in configuring their networks.

The Standards Promotion and Application Group (SPAG), originally composed of 12 leading European manufacturers of information technology (IT) products but now having a broader membership, was founded in 1983 at the request of the European Commission (EC). The EC's initial objective was to receive guidance from SPAG in the promulgation of a European Information Technology Standards Policy for providing a homogeneous and wider European market for IT products. The resultant European policy, which is also followed by the European Free Trade Area (EFTA), has targeted OSI implementation as the basis for public procurement for 17 European countries, to start in 1992. According to this plan, all member countries will eventually adopt the functional standards published as "European Standards" (ENs developed by EWOS) which in the ideal and stable case "shall be implemented nationally by the publication of a National standard identical in presentation and content." With the initiation of EWOS, SPAG directed its attention away from profile development (the work that has been the basis for ENs) toward testing. SPAG views itself as and R&D group for the shareholders use, and will research and develop (or acquire) state-of-the-art testing tools.

The Corporation for Open Systems (COS) International is a not-for-profit research and development consortium, started in 1986 with the long-term goal of accelerating the introduction of interoperable, multivendor products and services operating under agreed-to OSI, Integrated Services Digital Network (ISDN), and related international standards. Its 65-plus members--communication and computer vendors and users-- are motivated by a desire to assess how vendors can best supply end users with conforming OSI and ISDN solutions to their networking needs, based on testing of implementations. The functional profiles to be tested by COS are found in the COS Profile Specification Document that is agreed upon by the Strategy Forum. The present document consists almost entirely of references to the relevant sections of the NIST OSI Workshop Implementors Agreements, and the appropriate base standards themselves. As ISPs are agreed upon in ISO, these will be referenced. The profiles contained within the COS program are selected from the universe of profiles; they are the ones that COS will test. The major COS deliverable, the COS Mark, acts as a facilitator of multi-vendor interoperability, and visible evidence that COS requirments have been met by the tested implementation.

The Japanese Promoting Conference for OSI (POSI) was founded in 1985 by six major computer manufacturers and Nippon Telephone and Telegraph (NTT). The purpose of POSI is P.R.: to promote OSI standards, as well as manufacturing in accordance with those standards, by exchanging information among the member companies and by cooperating with other groups worldwide. The Conference itself consists of executives of the member companies. The system for promoting OSI in Japan is complicated and POSI plays a leading role in developing OSI policy. Most of the technical work is done by INTAP (Interoperability Technology Association for Information Processing), which has among its responsibilities both OSI profile development and conformance testing. INTAP is authorized and funded by the Ministry for International Trade and Industry (MITI). POSI was instrumental in initiating the OSI workshop in Japan.

Government Documents:

Many governmental bodies worldwide, both national and regional, have already developed Information Technology (IT) policies making mandatory (or recommending strongly) (eventual) procurement of OSI computer products for public sector use. In addition to the European Community move toward ENs discussed above, these governmental entities include, among others, the United States, Japan, Canada, and Australia. The UK and US GOSIPS are briefly considered below.

The UK GOSIP is the responsibility of the Central Computer and Telecommunications Agency (CCTA) of HM Treasury. It precisely reflects CCTA's policy commitment to OSI, originally promulgated in 1984. GOSIP is a user application profile, intended to provide specific technical guidance to both government departments and equipment suppliers. GOSIP is complementary to other CCTA documents, such as Management Guides and surveys of major OSI-product suppliers. It also provides the user with CCTA's view of worldwide activities in conformance testing. The GOSIP specification as such is not mandatory for government departments but is expected to have wide application (beyond that of the public sector) and CCTA is "keen to encourage other major users to adopt identical or equivalent specifications so as not to fragment supplier's development resources." It is the stated intent of UK GOSIP to be as compatible as possible with other major profile efforts, including MAP, TOP, and US GOSIP.

US GOSIP, developed by the US Government's OSI Users Committee, is based on NIST Workshop Agreements. GOSIP addresses the need of the Federal Government to move immediately to OSI multi-vendor interconnectivity without sacrificing essential functionality already implemented in critical networking systems. Version 1.0 of this document (to be updated yearly in conjuntion with the NIST "Implementors Agreements") was issued as FIPS 146 (Federal Information Processing Standard) in 1988, and will soon be mandatory for Government users (although exceptions will apply). The FIPS 146 specifies applicability and implementation procedures; vendors are working to supply the OSI-conformant products to the market place. (Version 2 is already out for ballot.)

The EC, in a move to support its plan for extended use of OSI standards in public procurement, is planning to finance the development of a Procurement handbook for OSI (to be based on UK GOSIP) to be developed in concert by the UK, France, and West Germany. The first three areas to be addressed by the EPHOS project are X.25 wide area networking, X.400 message handling systems, and FTAM. Eventually, the scope of EPHOS will broaden to match UK GOSIP, moving toward a European GOSIP. While it is not seen as creating a legal standard, the handbook may be used as part of the EC's mandatory procurement directive. Project results are scheduled for publication in 1990.

In addition to the European efforts to harmonize GOSIP material, an international effort has been initiated that includes government groups from the US, Europe, Australia, Canada and Japan, called IPSIT, "International Public Service Information Technology". IPSIT is considering global issues such as a comparison of procurement profiles with a view to harmonisation; testing; inter-project communications; security requirements and applications portability. CCTA plans to set up an X.400 link with NIST to maintain frequent contact with US GOSIP. The IPSIT membership includes an EPHOS representative.

INTERNATIONAL STANDARDIZED PROFILES

In 1985, ISO TC97 (now ISO/IEC JTC1), "Information Processing Systems", considered if it had a role regarding the worldwide activities on the "groupings" of OSI base standards into functional "stacks." There were some who felt that this work of standards implementation was beyond the reach of ISO; others felt that the intrinsic interrelationship between the profiles and the standards made it imperative for ISO to become involved. In a decision that brought ISO into the "eye of the hurricane", a Special Group on Functional Standardization (SGFS) was chartered in January 1987 to do the following:

1. define the new international functional standards document;
2. classify functional profiles;
3. determine a methodology for achieving functional standardization;
4. develop a set of operating procedures;
5. execute an ISO review of proposed draft functional standards;
6. develop an expeditious publication procedure; and
7. decide on a maintenance plan.

The Special Group on Functional Standardization (hereafter called the SGFS) is now the ISO/IEC JTC 1/SGFS. The importance put on this work by ISO and IEC can be measured by the fact that the SGFS has the status of an ISO/IEC JTC1 subcommittee and reports directly to JTC1.

In November 1987, ISO and IEC jointly agreed to a new kind of publication, the "International Standardized Profile", the ISP, having the same status in the international community as an international standard. The ISP, the harmonized "Implementors Agreement", so to speak, is defined in ISO (in TR 10000) as "an internationally agreed to, harmonized document which identifies a group of standards, together with options and parameters, necessary to accomplish a function or set of functions."

Concurrently with the study on ISO's role in functional profile work, the ISO Executive Board and Council were examining the role of organizations worldwide (i.e., SPAG, POSI, COS, and MAP/TOP Users Groups) that were recognized as having a special interest in convergent OSI functional profile development. Even though these organizations had no special relationship with ISO or with each other at that time, representatives from these four organizations were invited to Geneva in October 1986 to brief the ISO Board on the status of activities and concerns with the ISO process, particularly relating to the need for base standards development needed for profile establishment. ISO referred to these four consortia organizations as "feeders", that is, feeders to ISO of a) priorities of needed base standards development, and b) (possibly) harmonized functional standards into an ISO-based process of recognition, approval, and publication. Consequently, ISO recognized the four "feeders" as special liaisons (S-liaisons) to the Special Group on Functional Standards. (ISO now refers to the S-liaisons not as "feeders" but as "OSI User Groups.") In mid 1989, the same status was given to the three regional OSI workshops, where the actual harmonization takes place worldwide. This special liaison status permits the groups to participate directly in the Special Group activities, rather than through any particular member National Body, but does not confer voting privileges.

The JTC1/SGFS has produced Technical Report, TR 10000, "Taxonomy Framework and Directory of Profiles", which documents those items (1-7, above) contained in its charter. Although it is envisioned that TR10000 will eventually be applicable to all areas of competence within JTC1, priority is given at this initial stage of development to profiles in the OSI area, i.e., those that specify OSI "base standards", and those expected to be used in conjunction with them. TR10000 is expected to be fully approved by JTC1 by the end of 1989.

According to TR10000, "base standards" are "those that specify single layer or multilayer procedures and formats that facilitate the exchange of information between systems. They provide options, anticipating the needs of a variety of applications and taking into account different capabilities of real systems and networks". For the purposes of ISPs, these base standards are restricted to international standards or CCITT Recommendations.

TR10000 is largely concerned with the concept of "profiles". A profile is defined as "A set of one or more base standards, and, where applicable, the identification of chosen classes, subsets, options and parameters of those base standards, necessary for accomplishing a particular function." One or more profiles, with accompanying text, constitutes an International Standardized Profile. Format and structure of the Profile and ISP are detailed in TR10000. The basic intent is that profiles shall not contradict base standards but shall make specific choices of permitted options for each base standard and of suitable values for parameters left unspecified in the base standards.

The profiles define combinations of base standards for the purposes of:

1. identifying the base standards, together with appropriate classes, subsets, options and parameters, necessary to accomplish identified functions for such purposes as interoperability;
2. providing a system of referencing the various uses of base standards which is meaningful to users and suppliers alike;
3. providing a means to enhance the availability for procurement of consistent implementations of functionally defined groups of base standards, which are expected to be the major components of real

application systems; and
4. promoting uniformity in the development of tests for systems that implement the functions associated with the profiles.

Accordingly, a profile:

1. shall leave open as few as possible of the options in the base standards to which it referes, to maximise the probability that implementations of the profile can interoperate;
2. shall not specify any requirements that would contradict or cause non-conformance to the base standards to which it refers;
3. may contain conformance requirements which are more specific and limited in scope than those of the base standard(s) to which it refers. While the capabilities and behavior specified in the profile will always be valid in terms of the base standards, a profile may exclude some valid optional capabilities and optional behavior permitted in those base standards.

In summary, then, the basic principles for OSI profile content state that: an OSI profile specifies the application of one or more OSI base standards in support of a specific requirement for communication between systems. It does not require any departure from the structure defined by the Basic Reference Model for OSI, nor does it define the total OSI functionality of a system, but only that part relevant to the function being defined.

The profile Taxonomy, the content of TR10000, Part 2, is the structure and classification within which profiles will fit. It gives a first-level specification of profiles, including any determined technical constraints. It both classifies them and also specifies a number of relationships among them. The presence of a profile name in the taxonomy is not an indication of merit or development.

The following classes of OSI profiles have been recognized so far:

1. T - Connection-mode Transport Profiles, related to subnetwork type
2. U - Connectionless-mode Transport Profiles, related to subnetwork type
3. A - Application Profiles using connection mode Transport Service (i.e., using T-Transport Profiles)
4. B - Application Profiles using connectionless-mode Transport Service (i.e., using U-Transport Profiles)
5. F - Interchange Format and Representation Profiles
6. R - Relay functions between T- or between U- Profiles

The groups recognized by the SGFS as authorized submitters of PDISPs to the JTC1 process are: JTC1 "P" members (national bodies), Subcommittees within JTC1 or other ISP Technical Committees with an ISP requirement, and organizations in "A" (e.g., CCITT) and "S" (e.g., COS, EWOS) liaison with JTC1/SGFS. According to the process for ISP approval, the submitting organization presents a fully completed document (the PDISP) to ISO through the JTC1 SGFS. The target time for ISP publication by ISO is 7-10 months from the time the PDISP is presented to the SGFS.

The submitted pDISP must be accompanied by an Explanatory Report, prepared by the submitter, which contains a number of items of important information, including details of a technical nature related to the base standards, the identified purpose of each profile, a statement on the degree of openness of the PDISP process and the extent of international harmonization achieved, etc. This document will most likely be developed outside of ISO procedures (although the document is based on approved standards) and may reach global consensus of interested parties (usually spoken of as "global harmonization" in this process) outside of ISO as well. For PDISPs submitted from one of the four "Feeder" organizations, the expectation is that the harmonization will have taken place among the various OSI workshops. The three workshops have formed a Regional Workshop Coordinating Committee to assure harmonization of common work, and agreed modes for harmonization of other work of common interest. The RWS-CC and the Feeder Forum are working closely together to advance harmonization of profile work.

The stages in the procedural mechanism for the development of an ISP are: a) the submitting organization announces to the SGFS its intent to develop and submit a "globally harmonized" document to the ISO process of review and approval; b) the SGFS "gears up" by appointing an expert "review team" to review the PDISP and accompanying materials; c) the PDISP and Explanatory Report are submitted to the special group (the 7-10 month clock starts); c) the Review Team prepares and distributes a Review Report; d) the PDISP advances to the DISP level and a ballot takes place according to JTC1 procedures; e) upon publication of the ISP, the submitting organization assumes responsibility as the maintenance authority for the ISP.

The process inherent in the submission of a PDISP to ISO for approval as an ISP differs from the traditional standards-development process in several ways. A correct perception of these differences is essential to a clear understanding of the ISP process under the ISO umbrella. Although there are similar (and even identical aspects) to both processes, any attempts to force-fit the "new wine" of the ISP process exactly into the "old skins" of the traditional standardization approval process are futile. It remains that the ISP work is a new activity for ISO, done in new ways and leading to new documents.

Some of these differences are:

ISO STANDARD	**ISPs**
Documents are prepared in ISO committees.	Documents may be prepared outside of the ISO process.
Consensus is required for each step of the process within the rules established by ISO.	The "Global Harmonization" is the responsibility of the submitter.
The process is guaranteed to be "open" (membership is broad based and balanced, procedures are fair and	The assurance of the "openness" of development is also the responsibility of the submitter.

regulated, reviews consider all comments, etc.).	
Each proposed standard has at least two Technical Committee votes (JTC1), i.e., for DIS and IS status).	The DISP is submitted to only one JTC1 vote (for ISP status).
Standards maintenance is the responsibility of ISO.	ISP Maintenance is the responsibility of the submitter.

The first trial run of the process is presently taking place. PDISP AFT11, "FTAM: Simple file transfer", was submitted by SPAG in August 1989.

After emerging as ISO-approved ISPs, the documents will be available for public use, and in particular will provide a basis for the development of uniform, internationally recognized test systems. The accomplishment of such a goal will eventually provide the acid test of the usefulness of maintaining such a pathway within the ISO world. It is not an exaggeration to state that the decision to establish the Special Group on Functional Standardization has embarked ISO and IEC on a new venture of such magnitude that the consequences of it will be played out for many years to come in the international arena.

TESTING

Conformance testing:

The next step to interoperable OSI systems and products is the conformance testing of implementations (usually based on a profile). Since it cannot be taken for granted by users that product implementations conform to OSI standards becasue of the reasons already elucidatd in this paper,, conformance testing is used to verify that the vendor's product's implementation of the specificiations in the relevant international communication standard(s) is correct.

Not surprisingly, the story of the initial conformance testing work, worldwide, mimics that of profile development in many ways. Accordingly, the major points to be made about conformance testing in this paper are that a) there have been many independent efforts, worldwide, to develop tests; b) ISO/IEC JTC1 is developing a methodology and framework testing standard to define and own the process; c) ISO/IEC JTC1 and other standards groups are becoming increasingly involved in adding conformance testing information to the base standards; d) the Workshops are encompassing testing; and e) the Feeder Forum has turned its attention to assuring the harmonization of conformance tests worldwide.

In the mid-eighties, the European Conformance Testing Service, CTS, was initiated by the EC, under the auspices of CEN/CENELEC, to promote conformance testing availability throughout Europe to support economic integration. Further, and even more importantly, the goal was and is to establish harmonised conformance testing services throughout Europe which provide mutual recognition of test results and certification; these tests should be internationally standardized, as well. The CTS-WAN program, now renamed the Open Systems Testing Consortium, operates to test computing and comunications products designed for intercommunication over Wide Area Networks, develops reference implmentations, and tests conformance to the relevant ISO protocol standards, CCIT Recommendations, and ENs. The European Committee for Information Technology Conformance Testing and Certification (ECITC) and several other european structures are in place to shore up the OSI procurement rules for 1992 and beyond.

In the United States, The Corporation for Open Systems, although having International membership, is the industry focus for OSI Conformance Testing. COS promotes widespread agreement on how to use appropriate international communications standards in product implementation, and sponsors testers to use in specifying that the implementation under test is conformant. COS, as an independent third party (first party testing is under consideration) awards the COS Mark to products that meet COS requirements and that adhere to the Profile Specification requirements endorsed by COS. Such requirements are designed to increase the likelihood of product interoperability.

For a successful test, COS grants permission to use the COS mark with the product. One goal of the vendors taking part in the process is that the Mark stand for something important to the users when prodcts are marketed. The user's confidence in the interoperability of different vendors' equipments will then bring OSI into the real world---on top of our desks. Although the Mark does not guarantee full interoperability, because no conformance test alone can do that, it does involve the committment by Vendors to work together to attempt to resolve interoperability problems between COS Mark products, should they arise. There is a problem resolution process, as well. By mid 1990, COS should have fully operational COS Mark Programs for MHS, FTAM and components. NIST has expressed confidence in COS as a GOSIP testing lab, but no decisions on GOSIP testing have yet been made. A FIPS on GOSIP testing is in process of approval.

In Japan, the technical organization INTAP both develops the implementation specifications and runs the INTAP Conformance Test Center. As the technical arm of MITI for Information Technology, its work relates closely to government procurement specifications.

The harmonizing of testing worldwide is of key concern to testing organizations and of the many multi-level efforts being made, only a few can be mentioned here. In a specific instance, the recently announced COS-SPAG Integrated Tool Set (ITS), covering a broad range of implementations, provides the user with the flexibility of running a single test system or whatever combinations of test systems necessary to meet the user's testing requirments. At present it is hoped that INTAP will be party to the COS/SPAG ITS agreements.

Over the past several years, organizations including COS, SPAG, POSI, MAP/TOP, NIST, and INTAP have been working toward one-stop worldwide testing through mutual cooperation with other testing organizations and joint development projects that promote international harmonization. COS, SPAG, and POSI have developed an initial strategic cooperation agreement providing for a common solution to conformance testing and common criteria for test laboratory accreditation.

ISO/IEC JTC1/SC21/WG1 is developing a multi-part international standard, ISO 9646, to give guidance to the conformance testers. (The equivalent CCITT work is in X.290.) ISO 9646, "Conformance Methodology and Framework", addresses the meaning of conformance, specifications for abstract test suites, the test notation language, testing methods, laboratory accreditation, etc. The standard also defines PICS, Protocol Implementation Conformance statements, against which testing will take place, as a vendor's statement of the capabilities and options which have been implemented in an OSI implementation or system and any features which have been omitted. The list of items that make up a PICS has now been added to the base standard writer's responsibility, although at this point in time very few standards have the tables completed. In addition, some standards writers are attempting to prepare test cases based on the PICS. Both of these tasks are extremely complicated and time consuming, and full agreement has yet to be reached on their development. In particular, it is hope that any group develo0ping test suites outside of ISO will submit them for international stadnardization. (The test cases for X.25, alone, exceed 750 pages.) Accordingly, ISO 9646 defines a conforming system or implementation as "one which is shown to satisfy both static and dynamic requirements, consistent with the capabilities and options stated in the PICS."

Interoperability Testing:

While conformance is a necessary condition, it is not on its own sufficient to guarantee interworking capabilty. Two conformant implementations may not interoperate for several reasons. Some of these are:

a. The two implementations have chosen to support different options that remained in the profile that affect interworking (profile is badly designed)
b. The Conformance Tests were not sufficiently rigorous, or were flawed (which is, of course, possible in the real world situation). Also, there may well be some aspect of the protocol, or some aspect of the behaviour of the implementation being tested, which the conformance tests did not exercise that affects interworking.
c. The technical content of the standard is flawed.
d. Their underlying layers cannot interoperate.

Interoperability testing is a much less formal, more ad hoc process than conformance testing. There are several extensive networks, worldwide, providing this service to vendors. these include OSInet (NIST-sponsored); Eurosinet in Europe; and OSIcom, Australia. During this year, 6 of these networks were combined to form a worldwide OSI-interoperability network called OSIone. A major goal of OSIone is "the establishment of a common platform for regional OSI networks so as to facilitate the promotion and advancement of worldwide OSI connectivity and interoperability". OSIone's launch is planned for Cebit '90, Hannover, in March. Among the implementations demonstrated will be EDI, ODA, X.500, X.400, and FTAM. A minimal registration plan for results of interoperability testing, as devised by NIST for OSInet, is being considered for use by OSIone.

CONCLUSION

The key message contained in the expanding work that is being done on OSI profile development is the accelerating drive, worldwide, toward the development of real OSI products. None of these efforts is being made in isolation; rather, extensive cooperative initiatives have been pursued and those discussed here represent only the tip of the iceberg.

The four "Feeders" -- COS, POSI, SPAG, and MAP/TOP Users Group -- have already forged numerous bi-lateral and multi-lateral harmonization agreements, and have been the catalysts in the harmonization efforts now in operation in the OSI Workshops. Additionally, public activities such as the June 1988 Enterprise Networking Event International, co-sponsored by MAP/TOP Users Group and COS, make visible OSI network implementation and testing. Increasingly, efforts are being made by various groups mentioned here to promote international harmonization of conformance tests and test methods to achieve globally accepted tests and test results and also to accelerate the availability of test facilities.

It is commonplace to assert that profiles are developed to provide the basis for OSI-product development and conformance testing with the ultimate goal of system interoperability. Therefore, if profiles implemented worldwide differ, the resultant products will not be fully interoperable even if they all "conform" to OSI standards.

The world of global intercommunication is a world of inevitable tension between the needs and requirements of individual companies, and even individual nations, on the one hand, and the advantages of a universal market for OSI products based on identical implementation profiles on the other. Governments of industrialized nations, the European Commission, ISO, IEC, major vendors, and carriers and users groups worldwide have all chosen to step into this paradoxical world to participate in the effort toward convergence. The activities indicated in this paper prove that the organizational and administrative differences in intent and function, as well as the advantages accruing to proprietary solutions, have been eclipsed by the common interest the participants have in worldwide interoperability. The immense tasks associated with international harmonization efforts as outlined in this paper give an order-of-magnitude extension to Marshall McLuhan's words of the 1960's: "The medium is the message". The global village is being born.
